TREATISE ON THE ORIGIN,
Progressive Improvement
AND PRESENT STATE,
OF THE
SILK MANUFACTURE.

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ADVERTISEMENT.

THE author of this treatise thinks it right to acknowledge the advantage which he has derived from several documents kindly and readily communicated to him by Mr. Dillon, of the house of Messrs. J. Morrison and Co. of this city. For the opinions expressed in the volume, however, the author alone is responsible.

It is gratifying also to notice the cheerful alacrity with which the humble class of mechanics have uniformly contributed their aid by supplying information upon points which they are peculiarly qualified to explain.

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A TREATISE
ON
THE ORIGIN, PROGRESSIVE IMPROVEMENT, AND
PRESENT STATE
OF THE
MANUFACTURE OF SILK.

PART I.

HISTORICAL ACCOUNT OF THE RISE, PROGRESS, AND PRESENT STATE OF THE CULTURE AND MANUFACTURE OF SILK.

CHAPTER I.

HISTORY OF SILK, TO THE PERIOD WHEN SILKWORMS WERE FIRST INTRODUCED INTO EUROPE.

TIME OF ITS EARLIEST USE UNCERTAIN. — FIRST PRODUCED AND ADOPTED IN THE EAST. — CHINA THE COUNTRY OF THE SILKWORM. — THE SERES OF THE ANCIENTS THE CHINESE OF THE MODERNS. — SILK MANUFACTURED AT AN EARLY PERIOD IN THE ISLAND OF COS. — CURIOUS PROCESS. — SILK AMONG THE PERSIAN SPOILS ACQUIRED BY ALEXANDER THE GREAT. — ARISTOTLE'S DESCRIPTION OF THE BOMBYX. — ABSURD NOTIONS OF DIFFERENT WRITERS. — SILK HIGHLY PRIZED AT ROME. — MARCUS ANTONINUS SENDS AMBASSADORS TO CHINA. — PERSIAN MONOPOLY. — ATTEMPTS OF JUSTINIAN TO DESTROY THIS. — HIS FAILURE. — INTRODUCTION OF THE SILKWORM INTO CONSTANTINOPLE. — IMPERIAL MANUFACTURE. — SILKWORMS SUCCESSFULLY REARED IN OTHER PARTS OF GREECE. — SURPRISE OF THE SOGDIAN AMBASSADOR. — DESTRUCTION OF MULBERRY TREES IN CHINA.

Silk, and the many textures wrought from this beautiful material, are so universally and familiarly known, that the peculiar manner of its production cannot fail to be a subject of interesting investigation.

It is a wonderful fact, that the thick velvet and the stiff brocade, the thin gauze and the delicate blonde, should all be formed from the product of the labours of a little worm; and we are irresistibly prompted to enquire how such results are accomplished.

To trace from their origin the progressive steps by which man has adapted to his use the various productions of nature, is rarely possible. All that can be collected concerning several of the important arts of life is, that they have flowed to us from the East, and that many among them have issued from China in a state of comparative perfectness. This is particularly the case with the subject of our present enquiry.

It is impossible to fix the period when man first divested the chrysalis of its dwelling, and discovered that the little yellow ball, which adhered to the leaf of the mulberry tree, could be evolved into a slender filament, and thence be made to form tissues of endless beauty and variety. From a certain point, we can trace the progressive improvements of the silk manufacture, but seek in vain for authentic information respecting its earliest origin: and, while compelled to assign the merit of this to the Chinese, we cannot account for the degree of excellence which the art had attained previous to the time when even the existence of the material became known in the West. This proficiency alone, however, affords sufficient proof that the manufacture was of no recent origin. The manual arts arrive at perfection by very slow degrees. Improvements resulting from invention, as distinguished from imitation, are seldom rapid; and if this position hold good as a general principle, it is more especially applicable to labours unassisted by any save the rudest machinery, and practised by a people who, so far at least as we are informed, could derive little aid from science.

Notwithstanding these disadvantages, the Chinese, in the remotest ages, produced sugar, silk, and many other manufactures, with a degree of excellence which even now is scarcely surpassed. Yet while other nations have been rapidly advancing in knowledge, they have remained stationary. Debarred from intercourse with their kind, less by the obstructions which they raised to the ingress of strangers, than by the vanity which led them to make so false an estimate of other nations, this extraordinary people drew upon the resources of their own intelligence for discoveries the most important, and pursued them to an useful end with industry the most persevering. Their industry remains, but the intelligence to which it owed its principal value appears to have been arrested.* In the faculty of imitating, they are still considered unrivalled; but this is a quality which would seem to place them in the train of other nations, rather than as taking the lead in discovery and civilisation.

The first introduction of Indian luxuries to the knowledge of the ancients, was accompanied by the most fabulous accounts of the regions of their production, and gave occasion for many absurd speculations. This state of ignorance was, no doubt, in a great part owing to the peculiar policy of the Chinese, who, habitually and exceedingly jealous of all other people, enveloped the practice of their various arts in so much mystery, that stratagem was often baffled in the endeavour to unravel it, leaving us indebted for the disclosure to fortuitous circumstances.

In the attempt here made to trace, from the dark ages of antiquity to the present time, the progress of a trade and manufacture so widely diffused over the civilised world as those of silk, chronological order is followed as closely as the nature of the enquiry will permit.

Reasons already stated lead us to consider it probable that the inhabitants of China enjoyed the use of silk from a period greatly anterior to its introduction elsewhere. By the written records of that country, we are told that the art of converting to their own advantage the labours of the silkworm was known and practised among them 2700 years before the commencement of the Christian æra. Their most ancient authorities represent the empresses of China as surrounded by their women, engaged in the occupations of hatching and rearing silkworms, and in weaving tissues from their produce. To the empress See-ling-shee, the consort of Hoang-tee, is ascribed the honour of having first observed the silk produced by the worms, of unravelling their cocoons, and of working the fine filament into a web of cloth.

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* Note A.

Silk is described by the ancients as coming first from *Serica* or *Sereinda*, that part of India which lies beyond the Ganges. *Seres* is the designation given by the Greeks and Romans to the people who inhabited those remote regions, and Sereinda is, apparently, a compound of *Seres* and *Indi*. The latter is a general term, applied by the ancients to all distant nations, with as little precision as India is now used by modern Europeans.

It is now so generally admitted that the Seres of the ancients are the Chinese of the moderns, that it is unnecessary to enter into any discussion in proof of this belief. *Se* is the name for silk in the Chinese language; this, by a faulty pronunciation, not uncommon in their frontier provinces, acquired the final *r*, thus changing the word into *Ser*, the very name adopted by the Greeks. We can, therefore, hardly doubt that these obtained the name, as well as the material itself, first from China.

The labours of the silkworm, whose produce holds so important a place among the luxuries of modern life, were, until the time of the emperor Justinian, wholly confined to China. Long before that period, however, not only were manufactures of silk introduced among the nations which then engaged in commercial pursuits, but the raw material gave employment to extensive manufactories in Persia, Tyre, Berytus, and elsewhere.

The celebrated historian Ammianus Marcellinus describes the Seres as a sedate and gentle people, who avoid all contentions with neighbouring nations, and are therefore exempt from the miseries and alarms of war. Being without the necessity for using offensive weapons, they are even unacquainted with them. Blessed with a fertile soil, and a delicious and salubrious climate, they are represented as passing their happy days in the most perfect tranquillity and delightful leisure, amid shady groves fanned by gentle breezes, and producing fleeces of downy wool, which, after being sprinkled with water, is combed off in the finest threads and woven into *sericum.**

Marcellinus proceeds to describe the Seres as being content with their own felicitous condition, and so reserved in their intercourse with the rest of mankind, that when foreigners venture within their boundaries for wrought and unwrought silk, and other valuable articles, they consider the price offered in silence, and transact their business without exchanging a word; a mode of traffic which is still practised in some eastern countries.

In the island of Kos, situated in the Archipelago, silk was manufactured at a very early period. Aristotle relates, that *bombykia*, or the stuff produced from the *bombyx* (the silkworm), was re-spun and re-wove by the industrious women of this island. Pamphila is celebrated as the inventress of this process. She unwove the precious material to recompose it in her loom into fabrics of a more extended texture; thus converting the substantial silks of the Seres into thin transparent gauze, obtaining in measure what was lost in substance. Attempts have been made to rob the inventress of all the merit belonging to this process, by identifying the bombykia with the raw material, which, it is said, Pamphila and her nymphs procured from Seres, and spun and wove into sericum or silk. But the fact of the reweaving rests upon too good authority to be doubted. It will be seen that the Roman ladies subsequently adopted this Pamphilian process.

Pliny asserts that the bombyx was a native of Kos; but it is not probable that the women of that island would, in such case, have recourse to the laborious operation of converting foreign finished goods into threads for their own weaving. It is, therefore, only reasonable to suppose, that whatever manufacture was carried on from the raw material, was, like that of Tyre or Berytus, composed of unwrought silk imported from the East. It is mentioned both by Theophanes and Zonaras, the Byzantine historians, that before silkworms were brought to Constantinople in the middle of the sixth century, no person in that capital knew that silk was produced by a worm; a tolerably strong evidence that none were reared so near to Constantinople as Kos.*

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* Note B.

Among all the rich materials gathered from various countries for the embellishment of the celebrated temple of Solomon, no mention is made of silk. The costly cloths used at its dedication, and appropriated to the service of the priesthood, are described as being of the finest linen. In Jerome's translation of the Bible, we find sericum enumerated among other articles of commerce sent to Tyre from Syria, 588 years before Christ. The supply must, however, have been exceedingly scanty, since, on the rebuilding of the temple, which was completed sixty-four years after the last-mentioned period, the records of the Jews make no mention of the substitution of silken for linen fabrics, as might reasonably be expected among a people who introduced so much magnificence into their religious rites.

The victorious army of Alexander the Great brought home, among other eastern luxuries, wrought silks from Persia. This ambitious conqueror, while eagerly intent upon adding to his dominions, was desirous also of extending the boundaries of knowledge; not forgetting, amid his insatiable lust of empire, the more rational counsels of his learned preceptor, Aristotle, that he should explore the arcana of nature. To facilitate this object, Alexander took with him, in his Asiatic expedition, 1000 men, whose sole employment it was to collect animals, either by fishing, hunting, or hawking: these were, from time to time, carefully transmitted for the inspection of the philosopher; and for his further encouragement in the prosecution of his enquiries, Alexander presented him with the sum of 800 talents. So well did Aristotle avail himself of these opportunities afforded by his royal pupil, that although his writings on natural history are the most ancient extant, they are yet found to be more correct than those of many who wrote at later periods on that branch of science.

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* Note C.

Aristotle certainly gives the best account of the silkworm that is to be found in any ancient author, describing it as a horned worm, which passes through several transformations, and produces bombykia. It is remarkable, however, that, although minute in his description of the worm, he yet fails to indicate the country of its origin.

Pliny, whose writings afford evidence of so much erudition, has given an account of the silkworm which greatly varies from that of the Grecian philosopher. Assyria is assigned by the Roman naturalist as the native country of the bombyx; and he transplants Pamphila and her manufacture to Ceos, an island on the opposite side of the Ægean Sea, near to the coast of Attica. He tells us, that the stuff which the women of Rome unravelled and wove anew, was made from a woolly substance, combed by the Seres from the leaves of trees, and that draperies formed of this material were imported from the country of the Seres.

During a period of nine centuries following the time of Aristotle, various writers* asserted that sericum was made, either from fleeces growing upon trees,

"Velleraque ut foliis depectant tenuia Seres, —"†

from the bark of trees, or from flowers. With that confusion of ideas which was unavoidable in attempting to describe what they did not understand, these writers mingled together what they had heard or read of silkworms feeding on mulberry leaves, with cotton growing upon shrubs, with flax, and with coir, or the inner rind of the cocoa-nut. Some few authors came nearer to the truth, and stated, that the silken filament was obtained from a species of spider or beetle. So slowly was the truth on this point disseminated, even among learned men, that Isidorus, bishop of Hispalis in Spain, though he lived a century after the introduction into Europe of silkworms and the manufacture of silk, was wholly ignorant upon the subject, and servilely copied Pliny; so prone is the scholar to obtain his information from books, rather than to seek for accurate ideas in the study of things.

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* Note D. † Virgil.

Silk was very little known in Europe before the reign of Augustus, and, during a long succeeding period, it remained extremely costly; only a small quantity reaching the imperial city, by a circuitous and expensive land and water carriage.

In the reign of Tiberius the use of oriental sericum was appropriated in Rome wholly to women of rank. Men were restrained by a law of the senate from clothing themselves with such effeminate apparel. This prohibition did not indeed prevent their using, during the heat of summer, the lighter and inferior fabrics of Cos, notwithstanding the disapproval of the graver people, whose frowns proved of little effect in counteracting the incitements of vanity. The extreme slightness and transparency of these textures, which were also adopted by such females as could not procure the more costly stuffs, furnished occasion for the censure and ridicule of the moralists and satirists of more than a century.*

Further to gratify the tastes of those whose circumstances did not allow them to adopt the use of so admired a material of dress, a fabric was invented, in which the costly filament was interwoven with a cheaper material. This manufacture was called *sub-sericum,* and was worn indiscriminately by males and females.

The accumulating wealth and increasing luxury of the Roman people caused the demand for silk manufactures to increase faster than their supply, and their price became exorbitantly high. In the second century, the emperor Marcus Antoninus sent, on this account, am-

* Note E.

bassadors to China, in order to open a more direct commercial intercourse with that country.* These ambassadors proceeded to their destination by the way of Egypt and India. The annals of the Chinese historian Ven-hien-tung record this embassy, which did not prove more successful than embassies to China in other days have been. The Persians were, for centuries, the channel of communication between Rome and China, and their caravans, laden with merchandise, traversed the whole extent of Asia, from the Chinese Ocean to the sea-coast of Syria.

The price of silk in Rome, during the third century, must have been very high, when, amid the grosser enormities and more wanton prodigalities of Heliogabalus, it is yet deemed worthy of mention and accusation, that he habited himself in a garment made wholly of that material, and which was thence called a *holosericum*. In the latter part of the same century we find the more prudent emperor Aurelian refusing to the entreaties of his empress a similar luxury, alleging that such could only be obtained in exchange for its weight in gold.†

The luxurious habits of the Romans accompanied them to Byzantium, and offered a rich harvest to the Persians, which they were long enabled to reap, owing to their monopoly of the trade with India and China. This desire of obtaining a continued supply of luxuries, to which the former had been long accustomed, has been much censured, as evincing degeneracy from the sterner virtues of their ancestors. It would be difficult, however, to show that the Romans of the fifth century, employing their superfluous wealth in giving a profitable direction to native industry, while encouraging that commercial enterprise to which they were indebted for imported gratifications, were inferior to their rude forefathers, who followed no trade save that of the sword, and whose commerce with other countries consisted in war, and rapine, and desolation.

Persia, in the prosecution of this intermedial traffic, furnished silks to the inhabitants of Constantinople at prices out of all proportion with their cost in the country of production. Their trade needed the infusion of some of the modern spirit of competition, so useful to the great class of consumers; or it probably was trammelled by the regulations and exactions of an arbitrary government.

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* Note F.

† Note G.

The Romans being at war with the Persians in the reign of Justinian, that monarch endeavoured to obtain supplies of Indian produce for his subjects through other channels. For this purpose he sent embassies to Elasbaan, king of Axuma, and Esimiphæus, who governed the Homerites, in Arabia Felix, then tributary to Axuma. Stimulated by the desire of gain, these princes fell readily into the views of Justinian; but, through their deficiency of skill and experience, were little able to fulfil their commercial engagements; and the price of silk rose in Constantinople to a height which obliged even the most luxurious in a great degree to forego its use. This state of privation must not be altogether ascribed to the external relations of the imperial government. The Phœnician manufacturers were still willing to supply their silken fabrics; but Justinian, with short-sighted rapacity, injured the trade, by burthening the importation with heavy duties, and still more by regulating the price at which merchants were allowed to dispose of their merchandise. The arbitrary orders of the emperor limited this price to a rate which, when converted into English money, was equal to 4*l.* 15*s.* 9*d.*, estimated in gold, for the pound avoirdupois. This price was really greater than a similar amount at the present day, the value in exchange of the precious metals having been much reduced by the greater richness of the mines since discovered, and by the superior methods used for working them. This interference of Justinian was enforced with the greatest strictness; the merchants engaged in the traffic were ruined; the scarcity of silk at Constantinople was converted into absolute privation; and the revenue of the emperor, the improvement of which was doubtless the great motive for interference, suffered in consequence.

The commerce of the Romans was in this state, as regarded the article of silk, when they obtained relief in a very extraordinary and unexpected manner. Two Persian monks, having been employed as missionaries in some of the Christian churches, which, according to Cosmas, were already established in different parts of India, had penetrated into the country of the Seres, or China. "There, amidst their pious occupations, they viewed with a curious eye the common dress of the Chinese, the manufactures of silk, and the myriads of silkworms, whose education, either on trees or in houses, had once been considered the labour of queens. They soon discovered that it was impracticable to transplant the short-lived insect, but that in the eggs a numerous progeny might be preserved, and multiplied in a distant climate." * They observed with interest the labours of the little creature, and strove to make themselves acquainted with all the manual arts employed in working up its productions into so great a variety of fabrics. On their return to the West, instead of communicating their knowledge thus acquired to their own countrymen, they proceeded on to Constantinople. The prospect of gain, or, as some have asserted, an indignant zeal, excited by seeing a lucrative branch of commerce engrossed by unbelieving nations, prompted them to impart to the emperor the secret, hitherto so well preserved by the Chinese, that silk was produced by a species of worm; and to acquaint him with their belief that the eggs of these might be successfully transported, and the insects propagated in his dominions. They likewise explained to Justinian the modes of preparing and manufacturing the slender filament, mysteries hitherto altogether unknown or but imperfectly understood in Europe. By the promise of a great reward, the monks were induced to return to China, and there, with much difficulty, eluding the vigil-

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* Robertson's Disquisitions on the Commerce of India D'Herbelot, Biblioth Orient. art *Harir*. Procopius, Hist. Arcan. Gibbon's Decline and Fall of the Roman Empire, chap xl.

ant jealousy of the Chinese, they succeeded in obtaining a quantity of silkworms' eggs. These they concealed in a hollow cane, and at length, in the year 552, conveyed them in safety to Constantinople. The eggs were hatched in the proper season by the warmth of manure; and the worms were fed with the leaves of the wild mulberry tree. These worms, in due time, spun their silk, and propagated under the careful tendance of the monks; who also instructed the Romans in the whole process of manufacturing their production.*

The insects thus produced were the progenitors of all the generations of silkworms which have since been reared in Europe and the western parts of Asia,—of the countless myriads whose constant and successive labours are engaged in supplying a great and still increasing demand. A caneful of the eggs of an oriental insect thus became the means of establishing a manufacture which fashion and luxury had already rendered important, and of saving vast sums annually to European nations, which in this respect had been so long dependent on and obliged to submit to the exactions of their oriental neighbours.

The desire of augmenting his revenue, that powerful motive with rulers both ancient and modern, induced the emperor Justinian to take the infant manufacture into his own hands: it was conducted under the management of his treasurer; and the weavers, apparently those brought from Tyre and Berytus, as well as others instructed by the monks, were compelled to work in the imperial manufactory.

The altered circumstances wherein the manufacture was thus placed, wrought a corresponding alteration in the mind of the emperor as to the price which it was fitting should be paid by his subjects for the indulgence of their vanity. Silks of the imperial manufacture were sold at prices prodigiously beyond those which he had formerly prohibited as excessive. An ounce weight of the fabric thus manufactured could not be obtained under the price of six pieces of gold. The article was thus rendered eightfold more expensive than it had been under the restriction before the silkworm was introduced. This was the price demanded for common colours; but when tinged with the royal hue, the fabric immediately assumed a quadruple value.

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* Procopius, De Bello Gothico, lib. iv. c. 17. Theophan. Byzant. apud Photium. Theophylact. lib. viii. et apud Photium. Zonaras, vol. iii. p. 50. edit. 1557.

Under these circumstances of imperial rapacity, the introduction of silkworms could not have much benefited the Roman people. But the exclusive rearing of silkworms, and the manufacture of their produce, did not long remain a merely royal prerogative. The discovery that the worm could conduct its labours with as much advantage in Europe as in the climes where it first became the object of human attention, was quickly made subservient to practical utility. The mulberry tree was planted with eager haste, and vast numbers of these valuable insect labourers were soon, nourished by their natural food, successfully reared in different parts of Greece, and particularly in the Peloponnesus.

The demand for silk from the East diminished; the subjects of the Greek emperors were no longer obliged to have recourse to Persia for a supply of this article, and thence a considerable change took place in the nature of the commercial intercourse with India.

The establishment of the Turkish power in Asia, about the middle of the sixth century, together with subsequent wars, had greatly interrupted the caravan trade between China and Persia. On the return of peace, the Sogdians, an Asiatic people, who had the greatest interest in the revival of the trade, persuaded the Turkish sovereign, to whom they were become subject, to send an embassy to Chosroes, king of Persia, to open a negotiation for this purpose. Maniak, a Sogdian prince, who was appointed ambassador, was instructed to request that the Sogdians might be allowed to supply the Persians with silk. The ambassador presented himself before the Persian monarch in the double character of merchant and envoy, carrying with him many bales of silken merchandise, for which he hoped to find purchasers among the Persians. But Chosroes, who thought the conveyance by sea to the Persian Gulf more advantageous to his subjects than this proposed traffic, was not disposed to lend a favourable ear to the negotiation, and rather uncourteously showed his contempt of the Sogdian traders. He bought up the whole of the silk which the ambassador had carried with him, and immediately destroyed it by fire, thus giving the most convincing proof of the little value which it held in his estimation.

After this the Persians and Chinese united against the Turks, who, to strengthen themselves, sought an alliance with Justin, the emperor of the Romans. Maniak was again appointed ambassador, and sent to negotiate the terms of the alliance; but disappointment, though from a dissimilar cause, attended this his second embassy. The sight of silkworms, and the establishments for manufacturing their produce, in Constantinople, were as unwelcome as unexpected; but he concealed his mortification, and, with perhaps an overstrained civility, acknowledged, that the Romans were already become as expert as the Chinese in the management of the worms and the manufacture of their silk.*

The Venetians, soon after this time, opened commercial relations with the Greek empire, and continued for many centuries the channel for supplying the western parts of Europe with silks. The estimation wherein this manufacture was held continued sufficiently high for it to be considered worthy of being made a regal gift. It appears that in the year 790 the emperor Charlemagne sent two silken vests to Offa king of Mercia.

It was fortunate for the European admirers of silken garments that they were thus rendered independent of oriental supplies; for, in the year 877, Baichu, a rebel, made himself master of most part of the Chinese empire. When Canfu, the port of resort for foreign merchants, fell into his hands, he wantonly massacred all the inhabitants, among whom it is said there were 120,000 foreign merchants, consisting of Mahometans, Jews, Christians, and Persees. The number must, doubtless, have been greatly exaggerated by the historian on this occasion; but the population of Canfu must have been very great, or no writer would have ventured upon recording so vast a number of sufferers.

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* Gibbon's Decline and Fall of the Roman Empire, chap. xlii.

This savage monster, Baichu, not content with warring on his own species, extended his cruelty to those insects which were here so peculiarly the care of man; devoting to indiscriminate destruction all those trees on which the silkworm was nourished, and consequently entirely destroying the silk trade during his reign. To complete the ruin of the country, he practised such extortions upon foreign merchants, that during his sway they altogether gave up trading with China.

In the year 938, according to Massoudi, Canfu had recovered from the calamities thus inflicted, and again became a place of resort to the Arabian merchants as well as for trading vessels from India.

Many kinds of silk manufactures, such as velvet, damask, and satin, remained unknown for a long period after this, during which time silk fabrics continued to be wrought in increasing abundance in the Roman territories, which, either directly or indirectly, supplied most parts of Europe, until the middle of the twelfth century. Although at this period (1146) the Roman empire was fast declining in the scale of nations, and its possessions were reduced within nearly the same limits as bounded modern European Turkey before its late dismemberment; still, even in their degenerate state, its once powerful people continued to excel other nations of Europe in the quality and variety of their manufactures, and in the ingenuity of their artisans. They alone possessed the valuable breed of silkworms which, 600 years before, had been transferred from the remotest extremity of the East; and none others, up to this time, had manufactured its costly spoils.

CHAPTER II.

HISTORY OF SILK CONTINUED, FROM THE PERIOD WHEN SILKWORMS WERE FIRST INTRODUCED INTO EUROPE.

DIFFUSION OF THE SILK MANUFACTURE. — SUCCESSFUL ESTABLISHMENT IN SICILY. — GRADUAL INTRODUCTION INTO OTHER PARTS OF EUROPE. — MARCO POLO. — HIS ACCOUNT OF THE PROSPERITY OF CHINA. — ENORMOUS QUANTITY OF SILK PRODUCED THERE. — PRODUCTION AND MANUFACTURE IN ITALY. — IN SPAIN. — IN FRANCE. — COMMERCE OF ANTWERP. — ACCEPTABLE GIFT TO QUEEN ELIZABETH. — MANUFACTURE OF SILK IN ENGLAND. — INVENTION OF THE STOCKING FRAME. — TARDINESS OF ITS ADOPTION.

It has been shown in the preceding chapter in what manner the culture of silk was introduced, and its manufacture laid open to the ingenuity of the western hemisphere. The extension of this branch of human ingenuity was at first exceedingly slow, and we have seen, that for a period of 600 years, it was wholly confined to the territories of the Greek empire. Its first diffusion followed upon the invasion of these territories by Roger I., king of Sicily, who, not content with carrying off the wealth of Athens, Thebes, and Corinth, as some fruits of his successful enterprise, also led into captivity a considerable number of silk-weavers, whom he compulsorily settled in Palermo, obliging them to impart to his subjects the knowledge of their art.

Without stepping aside to question the right of the royal marauder thus tyrannously to sever these unoffending artisans from the ties of country and kindred, we may yet be allowed to express some satisfaction at the consequences of his cruelty. It is well for the interests of humanity that blessings, although unsought and remote, do sometimes follow in the train of conquest; that wars are not always limited in their results to the exaltation of one individual, the downfall of another, the slaughter of thousands, and the misery of millions, but sometimes prove the harbingers of peaceful arts, heralds of science, and even deliverers from the yoke of slavery or superstition.

In twenty years from this forcible establishment of the manufacture, the silks of Sicily are described as having attained a decided excellence; "as being of diversified patterns and colours; some fancifully interwoven with gold; some richly adorned with figures; and others tastefully embellished with pearls."* The industry and ingenuity thus called forth, could not fail to exercise a beneficial influence over the character and condition of the Sicilians.

By degrees the knowledge of the several processes required in the art spread over the greater part of Italy, and was carried into Spain; but it was not until the reign of Francis I. that the silk manufacture took root in France. A still longer interval occurred before its adoption in England; and its introduction, even then, was very slow. There is no doubt, however, that the use of silk was extensively adopted in this country at an early period after the conquest; for in the year 1251, at the celebration of the marriage between Margaret, daughter of Henry III., and Alexander III., of Scotland, a most extravagant display of magnificence was made, and, on the nuptial day, 1000 English knights appeared in *cointises* of silk. These, however, were not retained during the entire festivities; but on the next day were thrown aside, to be replaced by robes equally gorgeous and splendid.

At the close of the thirteenth century, the celebrated traveller Marco Polo gave to the world a narrative of his wanderings, wherein is contained a particular and interesting account of Cambalu, the royal city of China. It would be irrelevant to the subject of this volume to repeat many details of its opulence; but this will be sufficiently evidenced by showing the abundance of silk in which it traded. "No fewer," he informs us, "than 1000 carriages and pack-horses, loaded with raw silk, make their daily entry into the city; and silks of various textures are manufactured to an immense extent." He describes the whole country of China to be filled with great, rich, and crowded cities, thronged with manufacturers of silk and other valuable merchandise.

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* Note H.

Several provinces of China are so fertile with mulberry trees, and their climate is so congenial to the nature of silkworms, that the quantity of silk produced is very great. Du Halde says, "Every body knows the abundance and beauty of the silk which is made throughout China." The ancients showed their knowledge of this abundance, when they called it the Kingdom of Silk; and the moderns know it from experience—for many nations both of Asia and of Europe draw from it the superabundance of its produce; and every year ships and caravans leave the country, laden with vast quantities of both the wrought and unwrought material. Yet although thus lavishly sent forth, still, such is the amount produced, that silken fabrics, either wrought of the simple material, or mixed with gold or silver, are consumed throughout the empire to an almost incredible amount. If any other proof were wanting of this inexhaustible abundance, it might be found in the 365 barks, which the two provinces of Nan-kin and Che-kiang alone send every year to the court, laden not only with pieces of wrought silk, satins, and velvets, of various kinds and colours, but even with rich and costly garments. To this evidence may also be added, the many hundred thousands of pounds' weight of wrought and unwrought silk, which the provinces pay each year, as tribute to the emperor.*

It has always appeared to be the policy of the rulers of this empire, to restrain rather than to encourage a taste for commercial enterprise among its people. Abounding in so many productions coveted by other nations, it is remarkable that they have at all times merely tolerated foreign commerce, esteeming the great influx of money which it pours into their country as of no advantage. Possessing, under their varied range of climate, not only all the necessaries and comforts, but even the luxuries of life, and believing that they are masters of every kind of knowledge that is useful to or attainable by man, they feel themselves wholly independent of foreign nations, and affect to look with contempt upon such less fortunate beings as are compelled to leave their own countries in search of Chinese superfluities.*

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* Nouvelle Relatior de la Chine.

Although the various periods when establishments for the production and manufacture of silk were first introduced into the different countries of Europe may be ascertained with a tolerable degree of exactness, yet some discrepancies occur in the many authors who have noticed the subject. The authority, therefore, of those among them whose assertions possess the least degree of probability, must be rejected. There is much discordance in the various accounts of the introduction of silkworms and the manufacture of their produce in Italy.

In the year 1203, when the Venetians became masters of those provinces of the Greek empire which were the principal seats of the silk trade, they would hardly omit or delay to transport the manufacture and the worms into their own equally favourable climate; and it is also reasonable to imagine, that the Genoese, when they obtained possession of Galata, would hasten to transfer such lucrative branches of industry to their own country. It may, perhaps, be subject of conjecture or controversy, in what precise manner, or at what period, the introduction took place into Italy; but it is certain that in the year 1306 the rearing of silkworms had become of so much importance in Modena as to yield a revenue to the state, and that this city had arrived at so much excellence in the production, that its silk was then esteemed the best in Lombardy. In the year 1327, it was either considered advisable to augment the revenue derived from the silk trade in Modena, or otherwise this branch of industry was found to be on the decline. At that time the magistrates passed a law, obliging every proprietor of an inclosure (without, however, specifying the extent of ground which rendered compliance with the law obligatory) to plant at least three mulberry trees*, and further ordering, that all cocoons, or silkworm pods, produced, should be publicly sold in the market, the buyer and seller paying each a tax to the revenue.

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* Note I.

Till the beginning of the sixteenth century, Bologna was the only city of Italy which possessed proper throwing mills, or the machinery requisite for twisting and preparing silken fibres for the weaver. Up to that period the Modenese were obliged to send their silk to be thrown at Bologna. At length the genius of invention or imitation roused them into sufficient energy to acquire the art of constructing and working adequate machinery for their own purpose, and thence this preliminary branch of the manufacture spread to other cities of Italy.

In the year 1300, many thousand people were employed in the silk manufacture at Florence, where it was then followed in a much greater degree than in any other of the states of Italy.

Not only was the manufacture adopted likewise in Venice, but it was held in such high esteem, that the business of a silk factory was considered a noble employment, and might be practised without degradation by the higher classes. This was equally the case with two other trades, — those of the glass-maker and druggist, which brought no contamination upon nobility in Venice. In a country where wealth was concentrated in the hands of the powerful, it was no doubt highly judicious thus to encourage its employment for objects of public advantage. A feeling, more or less powerful, has always existed in the minds of the high-born, against the employment of their time and wealth to purposes of commerce or manufactures. All trades, save only that of war, seem to have been held by them as in some sort degrading, and but little comporting with the dignity of aristocratic blood.

The total expulsion of the Christians from Syria occasioned Egypt to become once more an entrepôt for the greater part of the trade between the eastern and western regions of the world. The Egyptian government made the monopoly thus enjoyed by its subjects a fruitful source also of revenue, and imposed very heavy duties upon the transit of merchandise. Marino Sanuto, a noble Venetian, indignant at the impositions to which the European trader was subjected, and burning moreover with true catholic zeal, addressed a work to the pope under the quaint title of "Secrets of the Faithful," in which he proposed to suppress the Egyptian trade by force of arms. This production does not, however, appear to have been owing to the sudden ebullition of an evanescent interest, hastily sent forth for the immediate relief of his oppressed fellow-Christians: it was begun, as he informs us in his preface, in the year 1306, and was presented to his holiness in 1321; during all which period of his literary labour, the objects of his zeal were left exposed to all the grievous exactions of the Egyptian government. Viewing with envy and displeasure the vast amount of profits which the sultan and the Saracens derived from the trades in silk and sugar, he details a plan whereby this source of prosperity might at once be turned from the race of unbelievers. Observing that silk was already produced in considerable quantities in Apulia, Romania, Sicily, Crete, and Cyprus, and that its production might be still further extended in those places, he solemnly adjures every good Christian to refuse the purchase of any merely suspected to have come from the dominions of the sultan. All direct intercourse with the unbelievers is of course to be forbidden; and this prohibition to be strictly and universally enforced by stationary armed galleys for the intercepting of illicit traders. In conclusion, this crusader against stuffs and condiments, with all the intolerant bigotry, unrelieved and unredeemed by the chivalrous daring of Godfrey de Bouillon or our own lion-hearted Richard, calls upon the captain of the holy church to wage perpetual and equal war against the Saracens and those perfidious Christians who infringe his commands by trading with the unbelievers!

It is recorded that Henry V. of England, on his invasion of France, which led to the celebrated victory of Agincourt, occupied, by himself and his suite, two vessels, which were fitted up with all the magnificence of regal splendour. The one which had the honour of conveying his august person was called the King's Chamber, and was further distinguished by a sail of purple silk, on which were richly embroidered the arms of France and England. Henry's mind was not of an order to give way to the incitements of such luxury; and he must have been far too much engrossed by the mighty project in which he was embarked, for the indulgence of such a weakness. He could only, in adopting a show of magnificence so unusual, have been actuated by the desire of dazzling the minds of his unenlightened followers, and of exciting them to repose additional confidence in so potent a leader.

Spain, as well as Italy, had at this time made considerable progress in the production and manufacture of silk. When Ferdinand V. conquered Granada, and put an end to the Moorish power in Spain, he found there numerous establishments for the production of silken fabrics, which were rivalled by others carried on in Murcia and Cordova.

It is said that the first introduction of silk into France was accomplished by Louis XI., who obtained workmen from Genoa, Venice, and Florence, and established them at Tours in the year 1480, under very extensive privileges. It does not, however, appear that much progress was made in the manufacture until the reign of Francis I. During the time that the French possessed the duchy of Milan (1521), artisans were thence procured, who introduced the manufacture into Lyons under the fostering protection of the monarch. The people of France made a rapid progress in this pursuit; and, in addition to those of Lyons, many manufactories were speedily established in others of the southern provinces, supplying sufficient for their own consumption, and soon afterwards even a superabundance for competition in foreign markets, furnishing many parts of Europe with the fruits of their newly cultivated art. In particular, France for many years derived considerable wealth from prosecuting this branch of trade with England.

According to Thuanus, the first introduction of the silkworm into France was during the reign of Francis I. This author relates that flourishing establishments for rearing silkworms were then to be found in Provence, at Avignon, and Lyons. Much attention was bestowed upon this subject at Fontainebleau, but the climate did not prove congenial to the habits of the insect.

In the year 1554, a sumptuary law was made in England, during the reign of the arbitrary and tyrannical Mary, whose declared object was the encouragement of home manufactures, and to restrain the growing vanity of the lower classes of the people. This statute, which affords evidence of the increasing intelligence and growing comforts of the middle class of English citizens, enacts, "That whoever shall wear silk in or upon his or her hat, bonnet, or girdle, scabbard, hose, shoes, or spur leather, shall be imprisoned during three months, and forfeit ten pounds;" excepting from this restraint magistrates of corporations, and all other persons of still higher condition. In the first year of the reign of James I. this absurd statute was repealed.

Guicciardini, in his description of the Netherlands, gives a long account of the prosperity of the city of Antwerp in the middle of the sixteenth century, which shows the great trade then existing in silk, and points out the countries which exported or imported that article. The merchants of Antwerp exchanged at Bologna their own serges and other stuffs, tapestries, linens, merceries, &c. for wrought silks, cloth of gold and silver, crapes, &c. To Venice they sent jewels and pearls, and the cloth and wool of England, and received in return the finest and richest wrought silks, &c. Naples took from them cloths of their own and of English manufacture, stuffs, tapestries, &c., and returned raw, thrown, and wrought silks, &c. Sicily obtained from them serges, cloths, &c., and paid for them in cotton, silk, &c. The consignments of Milan were pepper, sugar, &c.; the returns, wrought silks. To Florence and Genoa, woollen stuffs, English wool, &c.: the imports from the first of these places were very fine wrought silk; and from Genoa, other wrought silks, satins, and velvet.

It would naturally be imagined, from this view of the trade of Antwerp, that its citizens were extremely partial to garments of silk, and that these formed a common article of their dress; but of all which they thus received in such profusion, no part was appropriated to their own use. "Never any country," said sir William Temple, "traded so much, and consumed so little. They buy infinitely, but it is to sell again. They are the great masters of Indian spices and Persian silks, yet wear plain linen, and feed upon their own fish and roots; they sell the finest of their own cloth to France, and buy coarse cloth out of England for their own wear; they send abroad the best of their own butter, and buy the cheapest out of Ireland or the north of England for their own use. In short, they furnish infinite luxury which they never practise, and traffic in pleasures which they never taste."

It is related by Howell, in his "History of the World," that queen Elizabeth, in the third year of her reign (1560), was gratified by being presented with a pair of knit black silk stockings by Mrs. Montague, her silkwoman, at which she was so much delighted that she never afterwards condescended to wear those of cloth. It might have been supposed that Elizabeth's inordinate fondness for dress would have induced her to give every encouragement to the manufacture of so elegant a fabric as silk: it does not, however, appear that much progress was made in it during her reign. Content, probably, with her own acquisition, she might be desirous that the more becoming silken texture should remain a regal privilege; and while she displayed her own ancles in the delicate silken knit, was, perhaps, well pleased that her maids of honour should conceal theirs under the clumsy and inelegant cloth hose, lest, haply, among these some might have been found rather more beautifully formed than her own.

Henry VIII., that magnificent and expensive prince, could not in this respect indulge his vanity as successfully as his daughter, and was obliged to wear cloth hose, except when, by great chance, he was able to obtain a pair of silk stockings for gala days from Spain. Sir Thomas Gresham presented Edward VI. with a pair of long Spanish silk stockings; and, from their rarity, this offering was deemed worthy of much notice.

The city of Antwerp, having been, taken after an obstinate resistance, in the year 1585, by the duke of Parma, then governor of the Spanish Netherlands, it was consigned during three days to indiscriminate plunder and destruction. Its ruin was a death-blow to the commerce of the Low Countries, and the noble manufactures of Flanders and Brabant were dispersed into various countries. About a third part of the artisans and merchants who wrought and dealt in silk took refuge in England, where they finally settled, and taught those arts by which they had long prospered in their native land.

By these means the manufacture was very materially improved in England, and became one of national importance, so as to be the object of royal proclamations and legislative enactments for its regulation. For a long time, however, foreign silk goods continued to be preferred in this country; and in the year 1668 the tide of fashion set entirely in favour of French fabrics; so that it became a complaint that "the women's hats were turned into hoods made of French silk, whereby every maid-servant became a standing revenue to the French king of one half of her wages."

Notwithstanding this predilection for foreign goods, which may have existed independently of their merits when compared with English fabrics, that which was foreign being chosen merely because it *was* foreign—a sort of preference which is not, perhaps, without a parallel in even this more rational age,—notwithstanding this, the English manufacture has gone on steadily advancing in quality and amount, so as to afford one of the most striking instances on record, in which an art, borrowed from other nations, and employed on a material of entirely foreign growth, has been made at least to equal, if it does not surpass, the productions of those countries from which it was derived.

At the close of the sixteenth century, the English, who had previously been content to adopt the inventions and the plans of others, began upon that course of mechanical improvement, which has since been prosecuted to such important results. An engine for knitting or weaving stockings was at that time invented by the Rev. William Lea, of St. John's College, Cambridge, which was important, not only as it enabled our ancestors to discard their former inelegant hose, but likewise as it caused the English manufactures to excel all other foreign production, and to be sought after accordingly. The invention of this stocking frame enabled the manufacturer to export vast quantities of silk hose to Italy. These maintained their superiority for so long a period, that Keyslar, in his Travels through Europe, as late as the year 1730, remarks, that "at Naples, when a tradesman would highly recommend his silk stockings, he protests they are right English."

The success attendant upon Mr. Lea's invention was not, however, immediately consequent upon its introduction. On the contrary, the small use made of stockings in England at that time caused the machine to be long neglected; and so small was the encouragement which he met with at home, that Mr. Lea was led to comply with the invitation of Henry IV. of France, and, accompanied by several journeymen, established his looms for a time at Rouen, in Normandy. The subsequent assassination of his royal patron, and the consequent internal troubles of France, compelled him, however, to abandon this establishment; and falling into a state of destitution, he soon after died in Paris.

CHAP. III.

HISTORY OF SILK CONTINUED.—ATTEMPTS TO NATURALISE THE SILKWORM IN DIFFERENT COUNTRIES.

EXTENSION OF THE CULTURE IN FRANCE BY HENRY IV.—EFFORTS OF JAMES I. TO PROMOTE THE SAME OBJECT IN ENGLAND.—HIS FAILURE.—PARTIAL AND TEMPORARY SUCCESS IN AMERICAN COLONIES.—RENEWAL OF THE ATTEMPT IN ENGLAND.—SIGNAL SUCCESS IN INDIA.—EXERTIONS OF THE RUSSIAN GOVERNMENT.—SILK PRODUCED IN BAVARIA.—IN PRUSSIA.—IN THE MAURITIUS.—NOTICE OF AN ATTEMPT IN SWEDEN.—FORMATION OF A SILK COMPANY IN ENGLAND.—ENDEAVOUR TO PRODUCE SILK IN IRELAND.—THIS ATTEMPT ABANDONED.—HOPES OF SUCCESS IN MALTA.—RECENT ATTEMPT AT ST. HELENA.

Nearly at the close of the sixteenth century, the attention of Henry IV. of France was particularly turned towards enlarging the silk manufactures in his kingdom. The silkworm and the mulberry tree had been previously propagated in the Lyonnois, Dauphiné, Provence, and Languedoc; but the king now naturalised the insect as far north as Orleans, and brought silk to be a very general manufacture in France.

There had been no silk manufactories in Paris until the Parisians were encouraged by him to form establishments for this purpose. The letters patent which the king granted on this occasion are remarkable, as they conferred on success and perseverance in this pursuit no smaller rewards than titles of nobility. These were bestowed upon the first manufacturers, on condition that they should support the manufacture for twelve years. The ambition of sundry good citizens seems strongly to have excited them to weave, in this novel manner, the silken web of their exaltation; and the manufacture speedily flourished.

Mezeray says, that Henry also planted mulberry trees near Paris, and attempted to breed silkworms at the Tuileries, Fontainebleau, and the castle of Madrid.

These efforts appeared for a time to be attended with success; but later experience has shown that the silkworm cannot be profitably propagated in any place north of the river Loire. The climate in the neighbourhood of Paris is decidedly unfavourable to the attempt. The labours of the insect have, for a long period, been again confined to those departments of the south, whence Henry sought to colonise his more northern provinces.

The cultivation of the mulberry tree in France has been represented as occurring so early as the beginning of the fifteenth century, in the reign of Charles VIII., and its introduction ascribed to some of the nobles who accompanied that monarch in his Italian campaign. Other authorities as confidently assert that Sicily was the country whence the mulberry was first transplanted into France. However this may have been, its cultivation was at first confined to Provence, and was not even there attended with much success until the time of Henry IV.

In his endeavours to promote in every possible manner the production of silk in his dominions, this king offered great encouragement to the cultivators of mulberry trees, and established nurseries whence young trees were freely given to such landed proprietors as chose to apply for them.

Great anxiety has, at various times, been shown by the French government for the extension of this culture; but the greatest wisdom has not been always evinced in the choice of means for attaining their object. Colbert, minister of Louis XIV., in his impatience to increase the production of silk, did not content himself with merely giving trees from the royal nurseries, but also caused them to be removed, and planted at the government expense. This over-degree of liberality, however, defeated its object. The trees thus easily acquired were but little valued, and were either fatally neglected or wilfully destroyed by the peasantry. The error of the government was by this means soon made apparent, and a plan much more rational and efficacious was adopted. A reward of three livres was offered to the cultivator for every tree that should be found in a thriving condition three years after it had been planted. Thus stimulated, the cultivation was conducted with greater carefulness, and Provence, Languedoc, Dauphiné, Vivarais, Lyonnois, Gascony, and Saintonge became speedily covered with mulberry trees, although the production of silk was confined to the four first-named of these provinces.

The degree of success which attended the efforts of the French monarch to extend in his kingdom the production of silk, excited in James I. of England an active zeal for its introduction into this country. This object appears to have been a favourite with him, as he took great interest in stimulating his subjects to reduce it to practice. "Having seen," says king James, "that in a few years' space our brother the French king hath, since his coming to that crown, both begun and brought to perfection the making of silk in his country, whereby he has won to himself honour, and to his subjects a marvellous increase of wealth." *—After which preamble, he goes on to say, "that, from the experience of many private persons who had bred silkworms for their pleasure, nothing had appeared to cause a doubt that these may be nourished and reared in England, provided there were a sufficient number of mulberry-trees to supply them with food." To obtain this requisite, he is found, in the year 1608, sending circular letters to all the counties of England, strongly recommending the inhabitants to plant mulberry trees. He directed the persons to whom these letters were addressed to take the opportunity of the holding of the quarter-sessions, or of any other public meeting, to persuade and require those who were able, to buy and distribute in the counties the number of ten thousand mulberry plants, which were to be procured in London at the rate of three farthings per plant. Although at first the public feeling was averse

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* Harleian Miscellany, vol. ii.

to the novel undertaking, yet the continuance of the royal sanction and support, and a consideration of the advantages reaped by other European nations from this source, at length engendered a growing interest for the project.

It may also be collected from some of king James's speeches in the year 1620, that the people of England in general testified much interest on this subject. But, notwithstanding the royal countenance, the attempt was never attended by even partial success; our climate being evidently too cold for the rearing of silkworms with advantage. Several other trials, which have been made at later periods, have proved equally abortive.

James was likewise anxious to introduce the silkworm into his American colonies, and several times urged the Virginia company to promote the cultivation of mulberry trees and the breeding of silkworms. He addressed a letter to them expressly on this subject in the year 1622, conveying to them strict injunctions that they should use every exertion for this purpose, and should stimulate the colonists to apply themselves diligently and promptly to the breeding of silkworms and the establishment of silk-works; bestowing their labours rather in producing this rich commodity, than to the growth of "that pernicious and offensive weed" tobacco, an article to which his majesty has recorded and published his violent aversion.

The company, thus incited, showed much zeal in their endeavours to accomplish the king's wishes. They lost no time in transmitting his majesty's letter to the governor and council of Virginia, together with particular instructions how the colonists might best employ their labours in the production of silk. For the furtherance of this object, their instructions were accompanied by several copies of a work on the management of the silkworm, written by Mr. John Bonoeil. This gentleman, who was a member of the Virginia company, engaged warmly in the undertaking; and was so fully convinced of its practicability, as to assert that, with an adequate number of hands, such a quantity of silk might be produced in Virginia, as in a very short time would sufficiently supply all Christendom.

The misfortunes soon after this time experienced by the colony of Virginia, and which involved the dissolution of the company, materially checked the execution of this project. A considerable number of mulberry trees were planted, and flourished; but little silk was produced.

In the year 1654, the rearing of silkworms again became a subject of interest in Virginia. This revival was principally owing to the exertions of Mr. Edward Diggs, who confidently asserted that he had conquered all the main difficulties attending the experiment. He endeavoured to persuade the Virginians that in a short time a great quantity of silk might be very profitably obtained; but it does not appear that the production was ever carried to any extent in that colony. It is probable that the planters found a source of greater profit in the growth of tobacco, for which they met with a ready market both in the mother country and the north of Europe.

A renewed attempt to produce silk in England appears to have been made in the year 1629. This may be inferred from a grant having then been made to Walter Aston, of the custody of the garden, mulberry trees, and silkworms, near St. James's, in the county of Middlesex; although this may possibly have been a continuation of king James's project of the year 1608. The scheme was once again revived in 1718; a patent having at that time been granted to John Appleton, esq. for producing raw silk of the growth of England. To accomplish this undertaking, he was authorised to raise a fund by joint-stock subscription. This he accomplished, dividing the capital into shares of five pounds each. A deed of trust was executed, and enrolled in the court of chancery; directors for managing the concerns of the company were chosen by the subscribers, and Chelsea park, being conveniently situated, and possessing a soil favourable for the purpose, was fixed upon as the spot on which the operations should be conducted. A lease of this place for 122 years was obtained, and 2000 mulberry trees were soon actually planted; this forming but a small part, however, of the vast quantity, which the company contemplated raising. Many large edifices were erected at a great expense upon the spot, the remains of which are at present scarcely discernible. Mr. Henry Barham, who probably was a member of this company, published at this time an essay on the silkworm, wherein he laboured to prove that all objections and difficulties raised against the prosecution of what he calls "this glorious undertaking" were mere phantoms. The event, however, proved him to be wrong; and showed that difficulties did exist of an insurmountable description: for although it was confidently predicted that in the ensuing year a considerable quantity of raw silk would be produced, the expectation was disappointed, and the company soon sink into oblivion.

This undertaking had arisen among the crowd of speculations conceived at that period, which produced such disastrous results; projects, whether rational or chimerical, which were all alike eagerly embraced by the insensate multitude. The dreadful revulsion which followed may account for the rapid extinction of a scheme, the projectors of which had contemplated such splendid advantages.

In the earliest infancy of the settlement of Georgia, in the year 1732, a piece of ground, belonging to government, was allotted as a nursery plantation for white mulberry trees, and the attention of some of the settlers was soon engaged in rearing silkworms. This branch of industry gradually, although slowly, increased, both in Georgia and South Carolina; and it appearing desirable to government that this country should be enabled to draw supplies from its colonies, rather than be dependent upon foreign states for a material of continually growing importance to its manufactures, an act of parliament was passed in 1749 for encouraging the growth of colonial silk; under the provisions of which, all that was certified to be the production of Georgia and Carolina was exempted from the payment of duty on importation into the port of London. Encouraged by the increasing growth of raw silk in these colonies, which induced a belief, that by the adoption of more judicious plans an abundant supply might be drawn from them, sufficient to answer all the demands of our manufacturers, a bounty was offered for the production of silk, and an Italian gentleman, named Ortolengi, was engaged, at a suitable salary, to proceed to Georgia and instruct the colonists in the Italian mode of management. Although, for a time, hopes were entertained that the Georgians might find in this pursuit a valuable branch of industry; yet, in consequence of one or two unfavourable seasons, and still more from the quality of the silk proving very indifferent, its culture soon began to decline, and the lessening of the bounty became a signal for its abandonment by the planters. A small quantity was still raised by the poorest of the peasantry; but before the close of the eighteenth century the production of silk was wholly discontinued in Georgia.

There is no doubt that the cultivation of the cotton plant, which in the mean time had been introduced, proved so advantageous to the planters in Georgia, as to render a further prosecution of the precarious and less profitable silk product distasteful.

The rearing of silkworms had been an object of interest in Carolina so early as the year 1732. This branch of industry was undertaken principally by the small farmers, many of whom produced from forty to fifty pounds' weight of silk in the season. The endeavours to increase and perfect its production in this colony were long persevered in. In the year 1771, Louis de St. Pierre made a representation to government, that at the expense of his whole fortune he had brought to perfection the art of making wine and the production of silk at New Bourdeaux. His specimens of wine and silk, which were transmitted to this country, were thought deserving of notice by the patriotic Society for the Encouragement of Arts, which testified its approbation of M. Saint Pierre's exertions by presenting him with their gold medal, accompanied with a premium of fifty pounds. Notwithstanding this stimulus to further efforts, the quantities afterwards raised were small, and the cost of production proved too great for successful competition with silk of other countries.

The truly useful society just mentioned persevered for a series of years in offering rewards for the production of silk in Great Britain and her colonies, and discontinued this encouragement only when all hope of accomplishing what appeared so desirable an object had ceased. The society has repeatedly brought into notice, and fostered, both by pecuniary gifts and honorary distinctions, various improvements suggested by labouring silk-weavers, who, but for its assistance, would have wanted the means of embodying and realising their conceptions. Descriptions of several of these improvements will be found in this volume.

Many parts of the southern states of America appear to be as well adapted for the cultivation of mulberry trees and the rearing of silkworms as the European countries in which they are already successfully produced. It is said that the principal difficulty with which the Americans had to contend in producing silk in these southern colonies arose out of the circumstances of the labouring population, which then consisted of negro slaves, who could not be made sufficiently attentive and skilful in the management of the business. This opinion receives confirmation from the fact, that the same pursuit proved, at one time, not only practicable but profitable in Connecticut, where land was comparatively high rented, but where careful and intelligent white labourers might be procured.

A project was formed many years back to extend the culture of the white mulberry tree over all the states of the American union, and a considerable number was planted in consequence. In the year 1789 a very extensive nursery of these trees was established near Philadelphia; another at Princetown, in New Jersey; one at New York, and a fourth in Long Island. The states considered it politic to establish these nurseries, with the idea that in the then unsettled state of Europe, emigrants from the silk countries might be allured to a place where provision was already made for enabling them to pursue their accustomed employment. This expectation does not appear in any case to have been realised.*

Establishments for producing both raw and wrought silk have long flourished in the settlements of British India, where proximity to the country of its original production, the fitness of the climate, and, above all, the cheapness of labour, have contributed to ensure complete success. The island of Cossimbuzar and its neighbourhood, in the province of Bengal, are particularly favourable to the labours of the silkworm. Since the year 1760 the quantity of raw silk produced in the territories of the East India Company has been very extensively increased, and an equal advance has been made in the improvement of its quality.

There are eight principal silk filatures or factories belonging to the company in Bengal. In every filature are employed, according to its size, from 3000 to 10,000 people; and if to these are added the mulberry planters, worm-feeders, &c., the number dependent on each establishment may be stated at from 10,000 to 40,000 men, women, and children.

Attempts have been made to introduce the silkworm into other parts of the company's possessions, especially on the coast of Coromandel. Dr. James Anderson, who was particularly zealous in promoting this among other useful undertakings, introduced mulberry trees at Madras, about the year 1770; and, finding that they grew luxuriantly, endeavoured to procure silkworms' eggs from Bengal. His first and second attempts failed; but the third, which with laudable perseverance he made in the year 1789, succeeded perfectly; and the advantages likely to accrue from the production of silk soon engaged several persons on different parts of the coast in breeding the worms. In a letter addressed by him to sir Joseph Banks, dated 26th January, 1792, Dr. Anderson says, "I have received accounts of the success of the silkworms at Palamcotta and Masulipatam; as well as of the recovery of these that had been diseased in the late rains at Trichinopoly; so that a breed of this insect is already established in an extent of 600 miles upon the coast." In a future chapter the increasing importance of this branch of Indian commerce will be shown.

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* Note K.

The production of silk has always been deemed an object worthy to engage the attention of those European sovereigns who take much interest in the welfare of their subjects. The dissimilitude of their own climates to that of the native country of the silkworm has not deterred these potentates from making the attempt. Peter the Great of Russia, so indefatigable in his endeavours to raise his country in the scale of nations, did not neglect any efforts to obtain for it this desirable object, and caused several mulberry plantations to be formed and carefully cultivated in many parts of his wide dominions. These have flourished even so far north as 54° of latitude.

The attempt to rear silkworms in the Russian dominions was begun under the auspices of the empress Catherine, who partook of the desire to promote the production of silk in her empire. For this purpose, she placed a colony upon an island called Achtouba, situated in the Volga, where a plantation of mulberry trees already existed. The colony consisted of four hundred men, besides females. To these she granted exemption for ten years from all imposts; after which term they were allowed to pay their capitation tax and other imposts in silk, taken at the value of ten roubles per pound.

Mr. Sievers, by employing the most careful and judicious management, reared silkworms successfully at Bauenhoff in Livonia, at the latter end of the last century. In a letter written by him to a scientific gentleman in England, Mr. Sievers relates, that at Kiovia, a poor tailor, a native of Upper Silesia, living in a house opposite to one of the mulberry gardens planted by Peter the Great, was induced to solace his leisure hours as well as to add to the scanty profits of his calling by the rearing of silkworms. In 1797, the third year after the commencement of his labours, he delivered twenty-five pounds of silk to the director of the imperial gardens, who, by order of the empress paid him for it at the rate of ten roubles per pound. The poor man expected that the year ensuing would increase his produce one fifth part.

The first riband that was attached to the decoration of the military order of St. George, was manufactured out of the produce received from the Achtouba colony; and, although coarse both in its texture and material, the empress averred with a smile, that never in her estimation had she worn finer silk. Establishments are now regularly formed in Russia for manufacturing silk of native production; and the inhabitants flatter themselves with the expectation that in a few years they shall become independent of Persia for the supply of this material.

It is said, that the rearing of silkworms has been successfully followed in Bavaria and other parts of Germany. The French protestant refugees carried the art to Brandenburg, where they settled, under the protection of the grand elector Frederic-William, at the end of the seventeenth century. Mayet, who wrote a book expressly upon the culture of silk in the Prussian dominions, relates, that in the year 1790, the baron de Heintz, Prussian minister of state, cultivated the mulberry, and produced silk upon his estate which was acknowledged to be equal to the finest product of the Milanese.

A short time before the English obtained possession of the isles of France and Bourbon, the French government attempted to introduce the rearing of silkworms in those islands; evincing thus a spirit very different from that which has usually governed the policy of countries towards their colonial dependencies. These have been too often considered as only outlets for superabundant productions, and sometimes even have been debarred from growing articles of use, for which nature has peculiarly fitted their climates, in order that the parent state may supply them at a dearer rate for its own undue advantage. In the case just mentioned, the government of France granted a sum of money to create rivals to its own silk growers, and sent out agents properly qualified to carry the plan into effect. The loss of their colonies necessarily rendered these attempts abortive. That the idea was in itself well founded, appears from the success which accompanied a similar attempt afterwards made in one of those colonies. When sir Robert Farquhar was appointed governor of the Mauritius, he procured silkworms' eggs from Bengal, and intrusted them to the management of M. Chazal. This was at the latter end of the year 1815. In the month of March following, about 80,000 cocoons had been already obtained, more than a fourth part of which was reserved to produce a brood for the following season.

Although M. Chazal had meanwhile distributed silkworms to many of the colonists, yet what he reserved and reared himself yielded, in 1817, more than 200 pounds' weight of silk, of which one bale, weighing 176 pounds, was conveyed to England in the following year. A specimen of this was presented to the Society for the Encouragement of Arts, from which M. Chazal claimed the premium which it offered for the growth of silk in British colonies. The absence of official documents, and the time necessarily consumed in obtaining these from so distant a possession, together with some other circumstances not important to be mentioned, caused considerable delay in the adjudication of his claim; but the requisite documents having then arrived, the society, in the year 1824, awarded to M. Chazal their large gold medal. The silk, which was carefully examined by some of the most eminent brokers in London, was said to be of tolerably good quality.

A few years ago, the Swedes attempted to rear the tender silkworm in their inhospitable climate, and with some appearance of success. In the *Stockholme Journall* for March, 1824, an interesting notice of the subject is to be found. After enumerating the motives which first instigated the Swedes to encourage the growth of silk in their country, the statement thus continues:—"The idea, indeed, is not new; and experiments made long ago presented encouraging results, though it appears that, until the present moment, the attempt has never been seriously made. Experiments instituted during the last year (1823) in Stockholm, for the purpose of discovering some indigenous tree capable of nourishing the silkworm, have procured silk of very fine quality. The culture of the mulberry tree is extending itself in the provinces; and important communications on the most convenient mode of rearing the worm have been generally promulgated. The silk so produced in Sweden has confirmed, in the amplest manner, the remark formerly made on the superior fineness and solidity of silk grown in the north, compared with that from more temperate climes; a fact that has received the unanimous sanction of the members of the Royal Society of Commerce, as well as of many silk manufacturers. It supports the ordinary preparation and dye equally with the best Indian silk, possessing the same brilliancy and the same softness. The silk also that has been grown for the last few years in Bavaria is superior to that produced in Italy."

Another attempt for the production of silk in the British dominions was made at the commencement of 1825, a period when the rage for new commercial projects was scarcely less violent, or its eventual revulsion less disastrous, than they were during and following the memorable speculations of 1718. The company which was formed for the purpose just mentioned was incorporated under the title of "The British, Irish, and Colonial Silk Company." This undertaking was supported by characters of the highest rank and respectability, many of whom were induced to give their countenance to the project, by a patriotic desire to ameliorate the condition of the Irish peasantry, by adding to their profitable sources of industry. The undertaking should by no means be ranked among speculative and delusive schemes, raised for purposes of evanescent profit to their projectors, and with little reference to ultimate consequences. A royal charter was obtained, and active measures were taken to promote the success of the design. A spot of ground, of about eighty acres, was selected, on the estate of the earl of Kingston, near Michelstown, in the county of Cork, and in this place nearly 400,000 trees of the white mulberry were transplanted. The whole proved unusually successful, very few trees having died, and many having in the first year of their transplantation put forth shoots twenty inches in length. A small but complete building for rearing silkworms was adapted on the plan of count Dandolo, and every thing seemed to promise that success which should attend judicious plans and well-directed energy. The experiment was also repeated on a more limited scale in England. Between 70,000 and 80,000 mulberry trees were planted on nineteen acres of fine rich soil situated near Slough. The trees flourished here as well as in Ireland; but the attempt to rear silkworms in the United Kingdom has been ultimately abandoned by this company. Its managers now turn the whole of their attention to an establishment in the island of Malta. This has hitherto been attended with success, and promises advantageous results to the proprietors of the company.

The cultivation of cotton, which had formerly been pursued at Malta, was checked by the increased production of Egypt, and the numerous population of that island were consequently reduced to great distress; this new enterprise, therefore, which offered to the Maltese a prospect of again turning their industry into a profitable channel, was hailed by them with enthusiasm. The nature of the climate, joined to other local advantages, promise a favourable result to the endeavours of the company on this island. The growth of the mulberry tree in Malta, where attention has been paid to its cultivation, is said to be more rapid by at least one third than in Italy.

The recent experience of this company leads to the conclusion, that if our moist and variable climate do not in itself offer a sufficient obstacle to the success of attempts at rearing the silkworm, there would still remain another objection, which, though fatal to such an undertaking, cannot on any account be deplored, namely, the high price of labour. Silk requires so much care and attention for its production, and so great a number of persons must be employed in an establishment for rearing silkworms, that it is only in countries where the number of the poorer class is great in proportion to capital, and where, consequently, labour must be extremely cheap, that the silkworm can be reared at an expense which offers successfully to compete with other regions. Even then the superior skill and knowledge of people to whom the silkworm has long been an object of attention will always ensure them a superiority over novices in the art. This was one cause of failure in Ireland. Unhappily, labour is not much better paid there than in Italy; but the ignorance and awkwardness of the Irish peasantry, in bestowing the necessary attentions upon the silkworms, an avocation totally differing from any to which they had previously been accustomed, afforded sufficient reason for rendering their employment unprofitable to the growers.

In the year 1826, some silkworms' eggs were sent to the island of St. Helena, that the production of silk might be attempted on that isolated spot. It is said that mulberry trees are already flourishing there, and that success may be expected to follow the experiment.

For a very long period silkworms have been reared in England as objects of curiosity or amusement; and almost every schoolboy can testify the success which has attended his cares in tending them. There is, indeed, no doubt, that with an equal degree of attention silk may be produced in England as well as in other countries situated in an equally high latitude; but the high price of labour will always prevent its culture becoming a source of profit to the producer in England.

Although the great increase of our manufactures, and the importance of our trade in and consumption of silk, are fully shown in another chapter, yet the history of silk cannot perhaps be better concluded than by drawing the reader's attention to the enormous quantity of this material used in England alone, amounting in each year to more than four millions of pounds' weight. Fourteen thousand millions of animated creatures annually live and die to supply this little corner of the world with an article of luxury! If astonishment be excited at this fact, let us extend our view into China, and survey the dense population of its widely spread region, who from the emperor on his throne to the peasant in the lowly hut, are indebted for their clothing to the labours of the silkworm.

CHAP. IV.

TRADE OF FOREIGN COUNTRIES IN SILK.

CHINA, FRANCE, ITALY, SICILY, TURKEY, SWITZERLAND, PRUSSIA, RUSSIA.

The preceding chapters have shown the times and modes in which silk was first introduced into different states and kingdoms. It is now proposed to give a brief sketch of the present condition of the trade and manufacture in some principal foreign countries.

China is still as productive of silk as in more remote times: it continues to form one of the principal internal trades of the empire, furnishing employment to a greater number of individuals than any other occupation. Sir George Staunton tells us, that women only are employed in Han-choo-foo in the fabrication of flowered and embroidered satins, as well as other varieties of the finer tissues, and that a vast number of workwomen are thus engaged in very extensive factories.*

The silkworm is reared in China, for the purposes of manufactures, south of the Yellow River, but not far beyond it; the most southern parts of the empire being unfavourable to its growth. Silk is produced in the greatest quantity in the neighbourhood of Nan-kin, in about the thirty-second degree of north latitude.

The Chinese faculty of imitation continues to be successfully exercised in the manufacture of silks: of this the American merchants are accustomed to avail themselves profitably, sending French patterns to China, which are then copied with an exactness which makes these imitations, in every respect save one, quite equal to the original fabrics. Being great economists, the Chinese are more sparing in the use of their materials, and the weight of the goods is perhaps one fifth less than that of the French: the latter, indeed, are considered to be unnecessarily prodigal of their material; and the Chinese imitations present more than an equivalent advantage, being obtained at far less cost than the French fabrics.

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* Staunton's Embassy, vol. ii. p. 432.

England imports a vast amount of both raw and wrought silks from China. The latter description is included in the official custom-house returns with Indian goods, on which account its quantity cannot be accurately stated. The importation of raw silk from China in the course of the year 1829 amounted to 600,000 pounds' weight.

The growth of silk in France is still confined exclusively to its southern provinces. Lyons, which is the greatest silk manufacturing city of France, furnishes very few silks of its own growth: it is, however, the great emporium whence the merchants of Paris and other cities obtain supplies; as all silks brought from other places, either by land or sea, are obliged at least to pass through Lyons. In the year 1540, Francis I. granted to this city the privilege of being an exclusive depôt, which was confirmed by various royal ordinances down to 1717. The rate of duty was altered by almost all these ordinances; but no documents are to be found whereby to ascertain what effect any of the different changes produced upon the silk trade or manufacture.

For a short period (from 1720 to 1722) the privilege of import and deposit was extended also to Dunkirk; but in the latter year it was again confined to Lyons, with the additional regulation, that no foreign silk should be imported into France by any other port than Marseilles, or by land except by the bridge Beauvoisin. This ordinance also decreed, that all the silk grown in France should be sent to Lyons for sale, where it was subjected to a duty of three and a half sols per pound, while silk of foreign growth was burdened with the heavier impost of fourteen sols per pound. The regulations which thus favoured Lyons at the expense of every other part of the French kingdom were not adopted with the view of obtaining revenue for the state, but with the single object of benefiting that one city. The amount received in duties was appropriated towards the payment of its municipal debts, which would appear to have been somewhat considerable, as the privilege was continued down to the period of the French revolution.

When Lyons was in its most flourishing state, it was computed that, on an average number of years, 6000 bales of silk, each weighing 160 pounds, passed through the city annually. Of these 1400 bales came from the Levant, 1600 from Sicily, 1500 from Italy, 300 from Spain, and 1200 from Languedoc, Provence, and Dauphiné. In the zenith of its former prosperity it had been reckoned, that Lyons employed 18,000 looms in silk manufactures. But the disastrous effects of the revocation of the edict of Nantes in 1685 gave a serious blow to this prosperity; and in the year 1698 the number of looms amounted only to 4000. This manufacture afterwards revived, and a great part of Europe long drew supplies of brocade and rich silks from Lyons.

The decay of the manufacture at Tours was not less remarkable. This city, before the revocation, could boast of possessing 800 mills for winding and preparing silk, and 8000 looms for weaving it; while 40,000 persons were employed in the manufacture: 3000 looms were then at work in the manufacture of ribands alone. But soon after the period mentioned, Tours employed only 70 mills, 1200 looms, and about 4000 workmen; while the consumption of silk, which in the time of its prosperity had amounted to 2400 bales of 160 to 200 pounds' weight each, had decreased to 700 or 800 bales.

The revolution, of necessity, caused much alteration in the general state of manufactures in France; but Lyons, although its exclusive privileges were withdrawn, remained, and still continues to be, the principal seat of the silk manufacture. At a very early period, this city had acquired celebrity for the brilliancy of its dyes, which were used, not only for its own manufactures, but also for those of Paris and Tours. So much jealousy did the government evince of retaining this superiority, that it prohibited the exportation of dyed silk, lest other countries should imitate and rival the beauty of French manufactured goods: a senseless prohibition, which obliged the silk merchants of France to forego a present advantage, lest at some future period it might possibly escape from them.

At the period when Savary wrote, it is stated that the manufacture of ribands had very much retrograded in France. Those made in Paris were considered as the best; but considerable quantities of an inferior quality were manufactured at Chaumont and St. Etienne. English ribands, which were then admitted into use in France, subject to a duty of four livres per pound, were greatly preferred by the Parisians to those of their own make, and we consequently enjoyed a considerable trade in them until the year 1701, when the importation of foreign silk goods into France was wholly prohibited.

The first frames used in France for weaving silk stockings were introduced into Paris, from England, in 1656. This manufacture spread so rapidly, that in sixteen years from that time the stocking weavers were considered of sufficient importance to be incorporated by royal ordinance, which at the same time indicated the kinds of silk that it was permitted the manufacturers to use in their construction. Various *arrêts* were issued by successive monarchs to regulate this branch of industry: from these it appears, that extensive stocking manufactories were established in numerous towns, to which, in the usual meddling spirit of the government, they were restricted in the year 1700. The stocking manufacture no longer exists in the greater part of those towns, but is principally carried on in the Cevennes.

It is stated, in the "Commerce du 19^{me} Siècle," that between the years 1688 and 1741 France annually exported to England manufactured silks to the amount of 12½ millions of francs. In 1765 the English government commenced its system of prohibition against the introduction of foreign silk goods; and to this circumstance it must, perhaps, be ascribed, that in the year 1784 the exportation of wrought silks from France to all countries amounted in value to only 25,600,000 francs. In 1789 it had increased to 29,745,000 francs.

Immediately after this, and during the early years of the revolutionary war, the quantity fell off very much; but after a time the trade somewhat revived.

In 1801 the value of exported wrought silk was 39,314,000 francs; in 1820 this had increased to 123,063,000 francs; in 1821 it was 111,689,000 francs; in 1822, 99,063,000 francs; and in 1823, 84,302,000 francs.

In 1786 Lyons employed 15,000 looms; the ferment of the incipient revolution reduced this number in the year 1789 one half; when there were 12,700 workmen employed. The state of the manufacture cannot be well ascertained during the convulsions of the revolution; but it is known that among the effects of that dreadful event, the number of silk looms was so reduced that in the year 1800 they amounted to no more than 3500, employing only 5800 artisans in the manufacture. After that time the trade greatly revived. In 1812 it employed 10,720 looms, and 15,506 workmen. In 1824 the silk looms of Lyons were said to amount to 24,000, employing 36,000 men. A Lyons newspaper of 1825 gives the exact number of factories in that year as being 8526, and the number of looms 20,101. Since that period both are said to be diminished. One of the causes of this diminution is, perhaps, to be found in the dispersion of looms among the villages comprised within a circle of ten or fifteen leagues round Lyons; provisions, and consequently labour, being cheaper in these places than in the city.

Foreign competition, and some inauspicious measures of internal policy, have also produced fluctuation in this manufacture; and we learn from the Lyons newspapers, as well as from other sources, that much misery has prevailed at intervals in that once flourishing city. In the beginning of 1829, the operative silk-weavers of Lyons were in so great distress that a public subscription was raised for their relief. At the meeting convened for this purpose it was stated, that, of 22,000 looms existing in the city and its immediate neighbourhood, not more than one third were in use, while the wages of those artisans who could obtain employment had, as a necessary consequence, fallen very considerably.

France produced in 1812, according to good authority, 987,000 pounds weight of raw silk, and imported a like quantity. The average annual consumption of the country for the years 1822 and 1823, was estimated at 1,600,000 pounds.

During the last sixteen years great efforts have been made to increase the cultivation of the mulberry and the production of silk in France. It is believed that, in consequence, the annual produce has, since the year 1814, been increased one third. A merchant of Lyons states, that foreign silk does not form more than one tenth or one eighth of the whole quantity now used in the French manufactories: thirty years ago one half was foreign. No very authentic information can, indeed, be obtained on this point. The want of even approximative notions respecting the growth of silk in France cannot be better exemplified than by contrasting statements furnished by those who profess to have good information on the subject. In "Le Commerce du 19^{me} Siècle," the annual produce of 1825 is stated to amount in value to 15½ millions of francs. Estimating the average value per pound at 22 francs, the quantity produced is found rather to exceed 700,000 pounds; and in the "Annals of Agriculture," published in 1828, the produce of raw silk is estimated to be of the value of 60 millions of francs, and in weight rather more than 2,700,000, if the price per pound be equally reckoned at 22 francs.

No information of a more accurate description can be acquired concerning the quantity of silk goods which form part of the external trade of the country. This cannot be ascertained even by reference to the French custom-house reports, as, when a declaration is made, which is not always the case, the *declared* is usually in the proportion of from one half to two thirds of the *real* value. The greater part is exported without any declaration of value; and, in particular, the quantity of goods smuggled into other countries is never noticed in their custom-house reports.

France prohibits the exportation of its raw silk; the reason assigned for which restriction is, that the country does not produce a supply sufficient for its own manufactories. It is difficult to see how France can possibly benefit by this prohibition, so long as the markets of Italy are open to her merchants, and foreign silk is continually passing through her territories for the supply of other countries. The raw silk which we receive from France is the produce of Italy, merely passing through the hands of French commission agents in its transit between the countries. In this way England is supplied with a large proportion of the raw silk which is imported from foreign European nations.

It is the policy adopted by some Italian states to prohibit the exportation of their raw silk. England is in consequence obliged to obtain a great part of the Italian silk which her manufacturers require, through France, into whose territory it is smuggled. An intermediate nation thus reaps a profit which, but for these absurd restrictions, would be acquired by the country of production.

It is impossible to conceive that these Italian governments can remain ignorant of this fact, which is notorious to all the world beside; and it is almost as difficult to imagine that they can believe the interests of their subjects to be protected, by placing restraints upon the exportation of their raw produce. Any country which produces superabundantly, would be plunged into far greater distress by the loss of a market, than would be experienced by the people of other countries whom it was sought to deprive of that superabundance. These can generally obtain the object of their wishes elsewhere, and, failing in this, may either find a substitute, or discover that the privation is easily supportable, while the cultivator, who has produced the articles thus unprofitably left upon his hands, is plunged into real and serious misery. When may we hope to see princes take a higher moral ground of action, and scorning to connive secretly at acts which they openly profess to discountenance? *

The raw silk imported direct from Italy into England comes from the ports of Nice, Genoa, and Leghorn. The quantity thus obtained does not equal that which is brought through France. A great quantity of raw and thrown silk is, however, annually exported from Italy into various other countries.

The average annual amount computed from the four years between 1807 and 1810 inclusive, was equal to the value of 81,407,810 Milan livres, or about two and a half millions of pounds sterling. The exportation consisted principally of organzine, or thrown silk, that is, silk twisted, or "thrown," in the mill in readiness for weaving. The aggregate proportion of every other description of silk was very inconsiderable. More than three millions of pounds † of organzine were exported in each of the years 1806 and 1807.

Sicily, into which island the silk manufacture was introduced at so early a period, still continues to derive much advantage from this branch of industry, which is considered as the second great source of riches to that island, the trade in corn ranking as the first.

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* Note I.

† About seven of these pounds are equal to five pounds avoirdupois.

In all ages since its first establishment, the rulers of that country appear to have encouraged this manufacture among its people. In 1752, the king of Naples established and invested with many privileges a commercial company at Messina, for erecting manufactories of silks, stuffs, and camblets.

It is computed that, on an average of years, a quantity of silk equal in value to a million of ducats (187,500*l.*) is annually exported from the island.

Palermo employs 900 looms; its exports, however, are very insignificant, most of its silk being woven for home use. There are about 1200 looms at Messina, and rather more at Catania. A variety of fabrics is made in the Messinese factories, but the material is seldom well reeled, dyed, or sorted, and the work is not well performed. Great part of this is exported to the Levant. Very little Sicilian silk finds its way to England: the length of its skein differs from the general importations, which circumstance is found to be inconvenient to the throwster, and the quality of the filament is unsuited to the general purposes of the manufacturer.

Turkey supplies England with a considerable quantity of raw silk. Our imports from that country average more than 300,000 pounds' weight annually. It is brought to us from Aleppo, Tripoli, Sayda, &c.; but Smyrna is the principal port of commerce, especially for the silk of Persia, which forms a great part of that which is imported from Turkey. The silks of Persia are brought to Smyrna in caravans during part of the year — from January to September. The caravans despatched in January are laden with the finest silk, and the quality is found to deteriorate with each following month. The silk of Persia comes chiefly from the provinces of Ghilan and Shirvan, and the city of Schamachia, situated near the edge of the Caspian Sea. It is said that in some years no less than 30,000 bales of silk have been sent from these three places. The produce of Ghilan is the most abundant in quantity and the best in quality.

Shirvan and Erivan rank next; then Mazanderan, and, lastly, Astrabad; but the latter is so inferior as to be usually employed in forming fabrics intermixed with cotton. It is seldom or never exported. The silk from these different places is stored at Ardevil or Ardebil, another Persian city, whence caravans set out for Smyrna, Aleppo, Scanderoon, and Constantinople.

The silk manufacture has of late years made such rapid progress in Switzerland as considerably to alarm the French manufacturers. This advance is entirely of recent date, and has been caused by the political state of France.

When, in the year 1810, Napoleon made such strenuous but vain efforts to destroy the commerce of England, and prohibited so strictly the admission of foreign cotton goods into France, the inhabitants settled about the lake of Zurich were extensively employed in the weaving of muslins. Losing by this prohibition their accustomed market, they transferred their labours to the manufacture of silk goods, as the one for which their previous habits best fitted them. Their course of industry was in this way changed with so much success and rapidity, that in a very few years they were able successfully to compete with their neighbours, in many branches of silk manufacture, in the German markets. When the Bourbon government was restored in France, the Swiss weavers were still further benefited by the injury brought on the French manufacturers through the internal policy of their government. The religious persecutions of 1815, 1816, and 1817, induced a considerable number of persons to emigrate from Lyons, carrying to Zurich their skill and industry. "Thus," as a writer in the *Précurseur* of Lyons remarks, "at this epoch, as well as in that of 1793, strangers profited and were enriched by our bloody quarrels: an important lesson, frequently given to governments, and but too often given in vain!"

In 1814, Zurich and its environs contained not more than 2000 looms. To so late a period as 1820, Germany was entirely supplied by France with wrought silks; but since that period the quantities of silk goods of Swiss manufacture poured into the markets of Frankfort and Leipzig have been so abundant as to interfere materially with the sales of the French merchants.

In the beginning of 1828, Zurich contained from 9000 to 10,000 silk looms, and some of its factories were considerable. Three of the largest of these gave employment to 2600 workmen, one of them alone maintaining 1204 artisans. Zurich at one time confined its manufacture to Florentines, and Basle to taffetas; in both these towns all other kinds of silk fabrics, with the exception of crape and satin, are now made; and in Basle the manufacture of ribands is become very considerable. At Berne, silk for umbrellas is manufactured on so extensive a scale as to supply Germany and the north of Europe with this article of constant consumption. At Schaffhausen and St. Gall, only fine cotton goods used formerly to be manufactured; but such is the encouragement offered by the recent success of other cantons, that silk manufactures have likewise been commenced in those places.

At Crevelt, in Prussia, are established very considerable factories of ribands and broad velvets, which not only find a very ready market in Germany and the north of Europe, but are likewise extensively exported into America.

The Russians are very active and enterprising in increasing and perfecting the silk manufactures of their own country, and have already attained to great excellence in them, being indefatigable in their endeavours to obtain skilful artisans. An anecdote, found in the *Précurseur* of the 25th of October, 1828, shows the degree to which they have succeeded in these efforts. A Russian merchant, in the preceding year, visited the warehouse of a silk merchant at Leipzig, who had also a house of business at Lyons. The Russian merchant purchased a dozen pieces of French silk, and with these obtained many patterns of various kinds of fabrics wrought in this material. At the fair of the following year, the astonishment and mortification of the German merchant were not a little excited, on finding his ex-purchaser converted into a competitor, and offering a complete assortment of silken stuffs manufactured at Novogorod, from the identical patterns which he had himself unwittingly furnished.

CHAP. V.

PROGRESS MADE IN ENGLAND IN THE MANUFACTURE OF AND TRADE IN SILK.

EARLIEST RECORDS OF THE INTRODUCTION OF SMALL WARES. — OF BROAD SILKS. — REVOCATION OF THE EDICT OF NANTES. — ROYAL LUSTRING COMPANY. — TREATY OF UTRECHT. — COMMERCIAL TREATY WITH FRANCE. — INTRODUCTION OF THROWING MACHINERY AT DERBY FROM PIEDMONT. — DISTRESS OF WEAVERS. — THEIR TUMELTUARY PROCEEDINGS. — PROHIBITORY LAWS. — SPITALFIELDS ACT. — BENGAL SILK. — REDUCTION OF DUTIES. — REMOVAL OF RESTRICTIONS ON FOREIGN IMPORTATIONS — REPEAL OF SPITALFIELDS ACTS. — GREAT EXTENSION OF SILK MANUFACTURE. — IMPROVEMENTS. — COMPARATIVE AMOUNT OF TRADE. — SMUGGLING. — COST OF MANUFACTURING IN FRANCE AND ENGLAND. — DUTIES AND DRAWBACKS.

THE earliest historical notice of the silk manufacture in England is contained in an act of parliament, passed in the year 1363 (37 Edward III. cap. 5. and 6.), to restrict different artificers, merchants, and shopkeepers to the manufacture of or trading in one particular kind of goods, according to their own choice, which they were required to make and declare by a certain day named in the act, and in which extraordinary restriction especial exception is made in favour of female brewers, bakers, weavers, spinsters, and other women employed upon works in wool, linen, or silk, in embroidery, &c. But this manufacture must have been of little importance, and appears to have made very slow progress, since in the year 1454, nearly a century later, a law was passed (33 Hen. VI. cap. 5.) for the protection of the silk women of London against the importation, for five years, of foreign articles, which were enumerated and described as similar to those manufactured by them; such articles comprising only small wares, such as "twined-ribands, chains, or girdles." This prohibition was further continued and extended to the protection of various other branches of native industry, in the year 1463, by an act (3 Edward IV. cap. 4.), to continue in force during the king's pleasure; which act, enumerating all the prohibited articles, specifies "laces, ribands, and fringes of silk, silk twined, silk embroidered, tires of silk, purses, and girdles."

We may further infer from this restriction, that the productions of the London silk women did not then equal in quality or in cheapness the manufactures sought to be excluded.

In the year 1482, the above-mentioned act being no longer in force, the English makers of silk goods were all thrown out of employment; and in consideration of their great distress, the importation of all such goods was prohibited for four years from that time.

Twenty-two years later, an act of parliament (19 Hen. VII. cap. 21.) prohibited the importation of "any manner of silk wrought either by itself, or with any other stuff, in ribands, laces, girdles, corses, and corses of tissues or points," upon pain of forfeiture of the same; and by the same act it was made lawful for any persons, as well foreigners as English, to import all other kinds of silk, as well as raw and unwrought silk, the above only excepted.

From this it may be plainly inferred, that no manufacture of broad silks was at that time practised within these kingdoms; and, indeed, lord Bacon, in his "History of King Henry VII.," notes this circumstance. It was only near the close of the reign of James I. that, upon some encouragement afforded by that monarch to Mr. Burlamach, a merchant of London, some silk throwsters, silk dyers, and broad weavers were brought from the continent of Europe, and a beginning was made in the manufacture of raw silk into broad silk fabrics, which has since become of so much profit and importance to the country, and which then increased so rapidly, that in the year 1629 the silk throwsters of London formed a body of sufficient importance to be incorporated, under the style of "the master, wardens, assistants, and commonalty of silk throwers."

The progress made in this branch of industry may be further collected from the terms of a proclamation, issued in the year 1630, by king Charles I., setting forth, "that the trade in silk within this realm, by the importation thereof raw from foreign parts, and throwing, dyeing, and working the same into manufactures here at home, is much increased within a few years past. But a fraud in the dyeing thereof being lately discovered, by adding to the weight of silk in the dye beyond a just proportion, by a false and deceitful mixture in the ingredients used in dyeing, whereby also the silk is weakened and corrupted, and the colour made worse; wherefore we strictly command, that no silk-dyer do hereafter use any slip, alder-bark, filings of iron, or other deceitful matter, in dyeing silk, either black or coloured; that no silk shall be dyed of any other black but Spanish black, and not of the dye called London black, or light weight; neither shall they dye any silk before the gum be fair boiled off from the silk, being raw."

The same monarch, in the year 1638, issued directions removing, in part, the prohibitions imposed by his former proclamation, and permitting such silk to be dyed upon the gum, commonly called hard-silk, as was proper for making tufted taffetas, figured satins, fine slight ribands, and ferret ribands, both black and coloured; and as his reason for this departure from his former directions stated, with a degree of candour, not always admitted into the edicts of princes, that he had now become better informed upon the subject. This order further directed, that no stuffs made of or mixed with silk should be imported, if of a less breadth than a full half yard, nail, and half nail, on pain of forfeiture.

It will be remarked that this misguided and unfortunate prince thus took upon himself to regulate, by the authority of proclamations, matters which had previously been ordered by acts of parliament. In many of these orders, the king was guided by his own impulses, or influenced by the persuasions of others, rather than by any sound or enlightened views of the nature of commerce; and he endeavoured to render the trade of the country subservient to his political and religious designs, without reference to that freedom which is essential to the success of all commercial enterprise. In another proclamation, issued by him for the reforming of abuses which it was alleged had crept into practice in the manufacture and breadth of silks, the weavers' company were empowered to admit into their commonalty a competent number of such persons, whether strangers or natives, as had exercised the trade of weaving for one year at least before the date of a new charter then recently granted to that company; provided the parties so admitted should be conformable to the laws of the realm, and to the constitution of the church of England; as though the fabrics which they wrought were susceptible of contamination if touched by heretical hands!

In the reign of his son these matters were brought once more under the more constitutional control of legislative enactments. We learn from the preamble of an act passed in the year 1661 (13 and 14 Car. II., cap. 15.), that the company of silk throwsters in London then employed above 40,000 men, women, and children; and, upon the petition of that company, an enactment provided, that none should set up in that trade without serving an apprenticeship of seven years, and becoming free of the throwsters' company.

Many acts of parliament were from time to time, during this reign, passed for the regulation of the manufacture and importation of silk; but these acts were subject to continual alterations or repeals, and seem to have had but little permanent influence.

In the year 1685, the revocation of the edict of Nantes compelled many merchants, manufacturers, and artificers to fly from France. The numbers of these emigrants have been variously stated by different writers, at from 300,000 to 1,000,000 persons. About 70,000 made their way to England and Ireland, with such property as the emergency of their case allowed them to carry away. A large number of them, who had been engaged in the fabrication of silks, resorted to Spitalfields, contributing much, by their knowledge and skill, to the improvement of the manufacture in England. The silks called alamodes and lustrings were introduced by them; and we are also indebted to them for our manufactures in brocades, satins, black and coloured mantuas, black paduasoys, ducapes, watered tabbies, and black velvets, all of which fabrics had previously been imported.

Descendants of many of these refugees still are found in the same spot, engaged in the same occupation. The revocation of the edict of Nantes was attended with effects beneficial to other countries, which those who decreed that measure had not the skill to foresee. A large population, possessing knowledge and dexterity in the arts of life, were thus scattered over Europe, and intermingled with the less instructed of other nations. The cultivation of arts and manufactures was thus stimulated, and the general civilisation of Europe accelerated.

The manufacture of lustrings and alamode silks, then articles in general use, which, previously to the settlement of the French refugees in Spitalfields, had been imported from France, was, in the year 1692, brought to a state of considerable perfection; the persons engaged therein were this year incorporated by charter, under the name of "the royal lustring company," and obtained from parliament an act, prohibiting the importation of foreign lustrings and alamodes, alleging as the ground for such a restriction in their favour, that which, had it been well founded, should have made them indifferent to all legislative interference—that the manufacture of these articles in England had now reached a greater degree of perfection than was attained by foreigners. The author of a pamphlet, entitled "Angliæ Tutamen; or, the Safety of England," written in 1695, with the intention of discountenancing a great variety of joint-stock trading companies, which then were much patronised by the public, makes exceptions in favour of some few incorporations, and mentions, among these, the royal lustring company, as having thriven greatly, to the advantage of the manufacturing industry of the kingdom. In the sequel, however, this company suffered materially from the illegal importation of the prohibited articles; and, for its greater protection, a new charter was confirmed to it by act of parliament in 1698, whereby its powers and privileges were importantly enlarged, and the sole use, exercise, and benefit of making, dressing, and lustrating plain black alamodes, renforcés, and lustrings in England and Wales was granted to it for fourteen years. But this favoured corporation was doomed to encounter a deadlier foe than foreign competition, in a change of the public taste, and fabrics of a different texture coming to be generally worn, to the neglect of those in which they dealt, the company expended all its money, and was entirely broken up before the expiration of its charter.

The treaty of Utrecht, concluded in April, 1713, was accompanied by a commercial treaty with France, under which the manufactures of each kingdom were to be admitted into the other, upon the payment of low *ad valorem* duties. In this measure of liberal commercial policy, the government appears to have been too far in advance of the general intelligence of the people, whose commercial prejudices were so strongly excited, that petitions innumerable were presented to the parliament against its ratification; and after very violent debates, the bill for rendering the treaty of commerce effectual was rejected in the house of commons by a small majority. In the petition presented on this occasion by the weavers' company of London, it is stated, that, owing to the encouragement afforded by the crown and by divers acts of parliament, the silk manufacture at that time was twenty times greater in amount than in the year 1664; that all sorts of black and coloured silks, gold and silver stuffs, and ribands, were made here as good as those of French fabric; that black silk for hoods and scarfs, which, twenty-five years before, was all imported, was now made here to the annual value of more than 300,000*l.*, whereby a great increase had been occasioned in the exportation of woollen and other manufactured goods to Turkey and Italy, whence the raw silk was imported.

There seems to have been the less pretence for this opposition on the part of the silk trade, since it formed their boast that they had successfully imitated, and even outdone, the French manufacturers in the quality of those goods wherewith these had formerly supplied almost all the rest of Europe. And it appears to have wholly escaped the penetration of the government, that one argument upon which the weavers principally relied for the continuance of restrictive regulations in their favour, was capable, as regarded the general commercial benefit, of being more forcibly used against them: for if, in payment for the raw silk then imported, woollen and other manufactured goods were given, to how much greater an extent would these more natural branches of industry have been carried, if payment had been required for manufactured silk instead of the raw material? It is true that in such case the labour bestowed upon silk fabrics would have been so far lessened, but the demand for manufacturing labour throughout the kingdom would have been augmented rather than diminished, since a larger proportion of the value of woollen manufactures consists in the wages of artisans, than is the case with those of silk, whose original production is so much more costly; and even with reference to the operative weavers themselves, their hardships would not have equalled those which, in such circumstances, usually fall upon mechanics, since they would have found an employment for which they were qualified by previous habits and knowledge, in the weaving of those additional cloths and stuffs which would have been demanded. The truth of this statement has been recently confirmed by the transference of manufacturing industry from the cotton factories to the silk looms of Manchester and Macclesfield.

When, at a later period (September, 1786), a treaty of commerce was signed and confirmed between the two courts of France and England, under which the importation of many of the productions of either country was permitted into the other, on principles of reciprocal liberality, and subject to only moderate *ad valorem* duties, no evil consequences resulted to our manufacturers.

This treaty remained in force until the declaration of war by the French republic against this country in February, 1793; and during the entire six years of its continuance, although our shopkeepers were daily resorting to France for their purchases, and articles of French production were as commonly met with in our warehouses as were those of home manufacture, yet, during no period of our commercial annals have our manufactures experienced a more steadily progressive march of prosperity; for, if the taste of English consumers led many to prefer the fabrics of France, the tide of fashion in the latter country set with at least equal strength in favour of English goods, and the warehouses of London and Manchester became the resort of French merchants, to a degree which furnished constant and increasing employment to our artisans.

There can be little reason for doubting that, had the French commercial treaty of 1786 extended to the introduction of silk goods upon liberal terms, our weavers would, at a much earlier period, have placed their productions upon the same equality, in point of excellence, with those fabrics with which they would have come into competition, as they have, beyond all controversy, lately attained.

Up to the year 1718, our machinery for that purpose was so defective, that this country was, in a great degree, dependent upon the throwsters of Italy for the supply of organzined silk; but at that time Mr. Lombe of Derby, having, in the disguise of a common workman, succeeded in taking accurate drawings of silk-throwing machinery in Piedmont, erected a stupendous mill for that purpose on the river Derwent at Derby, and obtained a patent for the sole and exclusive property in the same during the space of fourteen years. This grand machine, was constructed with 26,586 wheels, and 97,746 movements, which worked 73,726 yards of organzine silk thread with every revolution of the water wheel whereby the machinery was actuated; and as this revolved three times in each minute, the almost inconceivable quantity of 318,504,960 yards of organzine could be produced daily. Only one water wheel was employed to give motion to the whole of this machinery, the contrivance of which, considering the then state of mechanical science in England, speaks highly for that of the constructor, who possessed the means of controlling and stopping any one or more of the movements at pleasure without obstructing the continued action of the rest. The building wherein this machinery was erected was of great extent, being five stories in height, and occupying one eighth of a mile in length. So long a time was occupied in the construction of this machinery, and so vast was the outlay it occasioned, that the original duration of the patent proved insufficient for the adequate remuneration of its enterprising founder, who, on these grounds, applied to parliament, in the year 1731, for an extension of the term for which his privilege had been granted. This, however, in consideration of the great national importance of the object, which was opposed to its continued limitation in the hands of any individual, was not granted; but parliament voted the sum of 14,000 pounds to sir Thomas Lombe, as some consideration for the eminent services rendered by him to the nation, in discovering and introducing, with so much personal risk and labour, and in bringing to perfection at great expense, a work so beneficial to this kingdom; the grant being made upon the sole condition that competent persons should be allowed to execute an exact model of the machinery, to be deposited in such place as his majesty should appoint, in order to diffuse and perpetuate the manufacture. The act authorising the issue of this money mentions, among other causes which justified the grant, the great obstruction offered to sir Thomas Lombe's undertaking by the king of Sardinia, in prohibiting the exportation of the raw silk which the engines were intended to work.

The imperfect records which, until a comparatively recent period, were kept of the progress of our commercial and manufacturing occupations, make it necessary to search in the pages of contemporary writers, in order to glean such information as may serve to denote that progress. In a work published in 1721, entitled "The British Merchant," and which bears marks of considerable authority upon mercantile subjects, it is stated (vol. ii. p. 220.), that the value of the silk manufacture in England amounted at that time to 700,000 pounds more than at the period of the revolution, when importations of wrought silks were made from France to the annual value of half a million sterling.

For the further encouragement of this manufacture, an act was passed (3 Geo. I. cap. 15.) for granting, during the space of three years then next ensuing, certain bounties on the exportation of fabrics composed wholly of silk, or of mixed materials whereof silk formed a portion. This concession in favour of the silk manufacture was one of the very few legislative interferences affecting the trade which has been founded in justice. The money granted on the exportation of wrought fabrics, although under the title of bounty, was, strictly speaking, only a drawback or repayment of part of the duties exacted on the importation of the raw material; and which, otherwise, placed the English manufacture at an unfair disadvantage in foreign markets.

It is stated that the silk manufacture of England had now been brought to so great perfection in all its branches as to equal the finest productions of any foreign nation; and this act for granting a drawback on exportation, was declared to have for its object "the giving of new encouragements to so noble a manufacture." By the same statute a farther advantage was afforded to the silk trade, by the repeal of all duties on the importation of drugs used in dyeing.

The Russia company, which enjoyed by charter the sole right of trading between England and Russia, obtained permission, in the year 1741, to import raw silk, the produce of Persia, from the dominions of the czar of Muscovy, upon payment of the same duties as were levied on the importation of the same article from the Levant. And it affords strong evidence of the favour wherewith the silk manufacture was still regarded by the English government, that they were willing so far to relax in its behalf the Navigation Act (12 Charles II.) which for so long a period had been, and which, even down to our own time, continued to be guarded with so much jealous watchfulness, as a main pillar of support for our commercial edifice. Considerable quantities of raw silk were imported in this way, and this branch of business long continued to prove highly profitable to the Russia company.

To meet the growing demand for the raw material on the part of the English silk throwster, parliament, in the year 1749, reduced the duties payable on the importations of raw silk by the East India Company from China to the same rate as was levied on that brought from Italy; and, in order to foster and extend the production of silk in the North American colonies of Georgia and Carolina, where already some considerable progress had been made in the pursuit, it was permitted to be brought thence to the port of London free of duty.

There is reason for believing that the so long boasted superiority of English silk fabrics over those of foreign production existed less in reality than in sanguine imagination and prejudice; since, in the face of such declared superiority, and under the burden of duties fully equivalent to those paid on the raw material by the British manufacturer, foreign goods continued to find their way to England, to the great dissatisfaction of the weavers, who, in a memorial presented by them to the lords of trade in the year 1764, prayed that, at least, double duties might be laid upon all foreign wrought silks. To this prayer their lordships do not seem to have given immediate attention; for in the following year, on the day appointed for the meeting of parliament (the 10th of January), the journeymen silk weavers of London, who were suffering from the then prevailing fashion of wearing French silks, assembled in vast numbers, and marched to the parliament house with drums beating and colours flying (as their successors have frequently done on subsequent occasions affecting their interests), in order to promote their petitions for relief, making personal application to the several members as they proceeded to the house of commons, and representing the wretched situation of themselves and their families. The weavers were at this time not contented with asking for the imposition of additional import duties in their favour, but prayed for the total prohibition of all foreign wrought silks.

The sight of such a multitude of people, who seemed ripe for the commission of almost any outrages, added to a report that the weavers were preparing to set out from inland towns in order to join their London brethren, caused a great consternation in the public generally, and more especially among the principal silk mercers, who, by dealing in the obnoxious articles, conceived themselves more exposed to resentment. To make their peace, these dealers came under engagements with the weavers to countermand all their orders for foreign silks; a contribution was made for the immediate relief of the sufferers, and parliament reduced the duties payable upon the importation of raw and thrown silks. By these measures the weavers were appeased; and the only violence committed by them consisted in breaking the windows of some of those mercers who dealt in silks of French manufacture.

At a later period of the session an act was passed prohibiting the trade in foreign manufactured silk stockings, silk mitts, and silk gloves; and the prohibition which already existed against the importation of ribands, laces, and girdles of silk, under the act of Henry VII., was now enforced with additional penalties.

These compliances, on the part of the legislature, with the demands of the weavers, do not appear to have produced all the beneficial results which were expected; as, in the very next year, it was rendered necessary, by their outrages, to pass an act, declaring it to be felony, and punishable with death, to break into any house or shop with the intention of maliciously damaging or destroying any silk goods in the process of manufacture. At the same time, the importation and sale were totally prohibited of all foreign made silks and velvets, with the only exceptions of those brought from India, and of silk crapes and tiffanies from Italy, but which last were burdened with an additional duty of seventeen shillings and sixpence for every pound weight, one half only of which was to be drawn back on exportation.

The journeymen weavers were, from this time, frequently led to form combinations for compelling the masters to raise the wages of their labour; and, in the month of October, 1769, notwithstanding the severity of the enactment just recited, and in defiance of it, frequent acts of violence were committed upon the property of their employers, and looms, together with the goods in them, were often destroyed. These riots were not suppressed without bloodshed, several soldiers, as well as some of the misguided weavers, being killed in the skirmishes.

The constant disputes which occurred between the journeymen and master weavers on the subject of wages, occasioned the passing of an act in the year 1773, whereby the aldermen of London for that city, and the magistrates of Middlesex for the county, were empowered to settle, in quarter sessions, the wages of journeymen silk weavers; and penalties were inflicted upon such masters as gave, and upon such journeymen as received or demanded, either more or less wages than should be thus settled by this authority. By the same act, all weavers of silk were restricted, under penalties, from having, at any one time, a greater number of apprentices than two.

This regulation, which applied only to the district of Spitalfields, and which was confirmed by two subsequent acts (32 Geo. III. cap. 44. and 51 Geo. III. cap. 7.), the first to include in its operation manufactures of silk mixed with other materials, and the second to extend its provisions to female weavers, continued in force until the year 1824. During its continuance it was the occasion of great difference of opinion among those affected by it. It is only during very recent years that a better understanding has been generally entertained of the principles which should influence the trading laws of a country. The favourable consequences which have followed the abandonment of many restrictions, once viewed with favour by the nation as being productive of commercial advantages, have proved how greatly those advantages were over-rated; or, to speak more correctly, how wholly the restrictions failed of attaining their intended objects, and how impossible they are to be upheld unless when accompanied by the forced and unnatural aid of war, during the continuance of which the strongest nation may dictate commercial as well as political law, and render other countries tributary to her aggrandisement.

Every legislative interference between the manufacturer and the working artisan must prove hurtful to the trade in which they are engaged. By tending unduly to augment the rate of wages, it must exercise an injurious effect upon consumption; and so much is this the case, that an augmentation in the price of a production, which would seem too small in amount for exercising any influence, has been known to ruin a manufacture altogether, by turning the public taste permanently into new channels, or by raising up competition from quarters unchecked by similar restraints.

There being a great scarcity in the beginning of the year 1779 of Italian organzined silk, which was indispensably required for the warp in silk manufactures, its importation was permitted from any port and under any flag until twenty days after the commencement of the next session of parliament; and this relaxation was extended from year to year, by successive acts of parliament, until the conclusion of the war.

In an estimate of the condition and the annual produce of the principal manufactures of Great Britain, which was published in the year 1783,* the different branches of silk manufacture were said to amount to the sum of 3,350,000*l.*, and it was farther stated, that this amount was progressively increasing. In 1784, additional duties were imposed of one shilling and ten-pence per pound on raw silk, and of two shillings per pound on thrown silk, and larger countervailing drawbacks were granted on the exportation of manufactured goods composed wholly or partially of silk.

The production of raw silk in Bengal, with the view to its exportation thence, was but of trifling amount until the middle of the eighteenth century; and its quality was so inferior as to occasion its sale for a price equal only to one third or one half that of Italian silk. The total quantity received from Bengal and China in the year 1750 was only 43,876 pounds; but soon after that period it became a favourite object with the East India Company to encourage its production, as one means whereby to draw from India to Europe the surplus revenues which were expected to flow into their coffers.

In the year 1772, with the view of rendering the silk of Bengal, which hitherto was of the commonest kind, and fit only for inferior purposes, acceptable to the English manufacturer, proper machinery and competent persons were sent to that country for the establishment of filatures, or silk-winding factories, on the Italian system. The period chosen was, in one respect, very unfortunate, owing to a dreadful famine which at that time visited India; and it was not until the year 1776 that any material advantage could be derived from this improved system. In the year just mentioned, the shipments of raw silk from Bengal alone amounted to 515,913 pounds; and during ten years, from 1776 to 1785 inclusive, the average importation reached 560,283 pounds. Although in some individual years the quantity has fallen short from accidental causes, yet its average amount has continued to advance with tolerable steadiness; and the importations now amount to nearly 1,500,000 pounds annually.

The quality of the East India Company's importations, although much improved by the use of the machinery sent from England in 1772, was still considered to be greatly inferior to that produced in Italy and Turkey; and, prior to the year 1794, it was thought applicable only to a very limited number of uses. This state of things, causing their importations to accumulate in their warehouses, led the directors to devise means for the more general introduction of Bengal silk into use; and, complying with the recommendation of a committee of their body appointed for the purpose, they, in the last-mentioned year, caused a portion of their stock to be converted into organzine by silk throwsters in this country. Although this measure encountered a strong opposition at that time from some branches of the silk trade, it was soon perceived to be of considerable benefit to the country, inasmuch as the experiment tended to remove much of the prejudice existing against the use of Bengal silk, and the trade was rendered less dependent upon Italy, whence, during so long a period, the greatest part of the organzine used by our weavers was brought. Up to this year (1794), the total quantity of silk organzined in the English mills did not exceed 50,000 pounds weight annually: the mills being principally occupied in working singles and trams, the importation of which descriptions was wholly prohibited; and as the English throwsters were often out of employment, they were willing enough to encourage this experiment on the part of the East India directors.

On the supposition that the quality of Bengal silk was suited to the objects for which organzine was required, there could be no difference of opinion concerning the policy of the step, since it was a means for providing profitable employment for English labour and capital. The opposition which had been offered to the measure proceeded from merchants interested in the importation of Italian thrown silk, who found means to influence, for a time, many among the manufacturers; but these, seeing at length that they were acting in opposition to their true interests, resumed the exercise of their own judgment, and employed organzined East India silk for many of their principal fabrics.

From that time the importations of Bengal silk have been progressively improving in quality; and, in consequence, the organzine made from it has grown gradually into favour, until it now ranks, for the most part, very little below Italian organzine, and, in some few instances, has even sold for the highest prices afforded by the market. Sanguine hopes have been expressed by some persons of competent judgment, that at no very distant day the improvement may be such as to render our manufacturers nearly independent of foreign supplies. The facilities for extending the production in India are such as to create reasonable expectations that, in regard both to quality and price, Bengal silk will force the productions of Italy, and the supplies from Turkey, out of the market. In these western countries there is but one regular annual crop, while in Bengal there are three, at intervals of four months, in March, July, and November.

The quality of China silk, governed by the same circumstances which limit the progress of improvement in all the institutions of that extraordinary country, has continued without variation from the period of its first introduction into Europe to the present hour. Its brilliant whiteness, the principal merit of China silk, is supposed to be owing to the application of some indigenous production, the knowledge of which is confined to that country. A great part of the raw silk imported from China is used in the fabrication of hosiery and gloves, in which articles it is acknowledged by foreigners that the English manufacturer has long greatly excelled the French, an advantage attributable to the superiority of machinery.

Bengal raw silk is distinguished by two appellations — country wound, and filature; the former being furnished by native adventurers, who can employ none but the rudest methods for winding it; while the latter is produced by servants of the East India Company, and treated according to the most approved European methods.

Different degrees of fineness or coarseness are denoted in the company's filatures in Bengal by the letters A, B, C; silk of 4 to 5 cocoons is called A No. 1.; of 6-8 cocoons, A No. 2.; of 8-10 cocoons, B No. 1.; of 10-12 cocoons, B No. 2.; of 12-14 and 16-18 cocoons, B No. 3.; of 18-20 cocoons, C No. 1.; of 20-22 cocoons, C No. 2.; 22-24, &c., cocoons, C No. 3. The silk which the natives reel by hand is much inferior, and is marked by the letters A, B, C, D, E. It must, therefore, be understood, that the A No. 1. silk of one district in India will differ very importantly in quality from that of another district, although bearing the same distinctive letter and number; this depending much upon the mode of culture, method of winding, &c. Even the filature-wound silks of different districts are subject to the same difference of quality. Thus, Bauleah filature is said to produce silk inferior in fineness to Radnagore or Cossimbazar filature, which, again, are excelled by the produce of Gonatea and Comercolly. In the last mentioned of these filatures, through the scientific skill and energy of the East India Company's resident, a system has lately been adopted of giving the necessary degree of heat to the cocoons while being wound, by means of steam; and both the arrangement and execution of the plans for this purpose speak very favourably for the talents of the parties employed, when the remoteness of the situation and the consequent difficulties and obstacles to be surmounted are taken into account.

The number of artisans needing employment was greatly augmented throughout the kingdom at the return of peace in the year 1815; and this event being soon afterwards followed by two bad harvests, the situation of the labouring poor was rendered still more distressing. The increased number of hands, and the rise in the price of provisions, conspired in reducing the rate of wages so low as to render it impossible for the labourer, even when fully employed, to obtain the quantity of the cheapest food necessary for subsistence. General complaint and discontent of course ensued.

The riband weavers of Coventry, and parts adjacent, having, early in the year 1818, petitioned the legislature for relief, their case was referred for investigation to a committee of the house of commons. A most laborious enquiry upon the subject was instituted; in the course of which they obtained evidence and information from great numbers of the most intelligent silk manufacturers and weavers of London, Coventry, Macclesfield, and, in short, of every district wherein the silk manufacture had seated itself in England. The result of this investigation proved that, although there doubtless was much individual misery among labouring artisans, arising from the causes just mentioned, there was no reason for imagining that any particular distress had visited those connected with the trade in silk; but, on the contrary, it appeared, from the concurring testimony of all the witnesses, that the quantity of silk goods manufactured and used throughout the kingdom was on the increase, and that, notwithstanding the greater number of looms, the weavers were all fully employed, and even forced to extend their toil beyond the usual hours to obtain support from the low rate of wages.

That, under these circumstances, the despairing artisans should seek relief, by any means which they thought likely to afford it, can excite no wonder; but that the master manufacturer, who saw one establishment after another rising up around him, while, at the same time, his own commercial transactions were continually extended, should declare his opinion that this increase of the trade was occasioned by the distress which accompanied it, and should pray, as a remedy, for the imposition of additional restrictions upon his trade, is somewhat surprising; and when, in compliance with this prayer, a committee of legislators are seen gravely recommending enactments, one of the first inevitable consequences of which would have been the aggravation of the evil, by throwing a large number of artisans out of employment, it becomes difficult to withhold the expression of astonishment. The house of commons spared itself the imprudence of carrying into effect this recommendation of their committee; and within three years from that time a committee of the house of lords recommended strenuously the entire abolition of those restrictions, the extension of which had so lately been declared "absolutely necessary."

During the whole of the period between the years 1773 and 1824 the silk trade in England was kept in its artificial state by restraints on the importation of foreign manufactured goods. Being thus secured in the possession of the home market, and in the supplying of our immediate dependencies, there was but little incitement for the weavers to improve their art. Thus the same inartificial loom, and the same throwing machinery, continued to be used down to the very moment when the competition of foreign artisans compelled the attention of our throwsters and weavers, and obliged them to devise means for more successfully meeting the productions of foreign looms in our own markets.

The silk goods of France had always found their way to this country, in a limited quantity, through smugglers; and being, in consequence of their then superior quality, eagerly sought by all who could procure them, our manufacturers were dismayed at the prospect of their legal admission, although loaded with heavy protecting duties. From being always wholly dependent upon home demand, the silk manufacture was liable to serious fluctuations with every change of fashion. The extensive sales of one season were frequently followed by the diminished consumption of the next. The weavers then deprived of employment would sink into the depth of wretchedness. This constant alternation of prosperity and distress had always attended the silk trade of England, although the preponderance of the former state was proved by the increasing amount of the manufacture, comparing one period with another in the course of years.

It was with a view to lessen this fluctuation, and meet the altered state of commerce attending the return of peace, and to place the silk trade upon a basis of natural capability, rather than of artificial support, that, in the year 1824, the whole system was changed. The high duty on raw silk was abandoned, for one merely nominal; that on thrown silk was reduced nearly one half, and the admission of foreign manufactured goods was rendered legal after the 5th of July, 1826.

It was hoped that the weavers, having so material a concession in their favour, in the alteration of the duties, would have been enabled, during the two years which must elapse before the admission of manufactured goods, to prepare for a successful rivalry with the foreign weaver; but they were led by the increased demand, consequent upon the abatement of duty, rather to employ their powers in augmenting the quantity than in improving the quality of their fabrics.

The local acts of 1773, regulating the wages of silk weavers in and about London, commonly called the Spitalfields Acts, the provisions of which had been subsequently applied to Dublin, were wholly repealed, as has already been mentioned, in the month of March, 1824. These acts were approved and defended by some persons well acquainted with the trade, on the ground that their operation tended to secure to the workman only fair and reasonable wages for his labour, and to prevent an exorbitant rise of poor rates. When the demand for any particular article of manufacture is slack, a competition among the artisans engaged in its production must always ensue, which, in the absence of prohibitory enactments, will lead them to accept less wages; and thus the articles of their production being furnished at lower prices, an increased demand is created, which brings things once more to their natural level. But the operation of this local act, by constantly maintaining the prices of goods at their highest point, lessened the chances of increased consumption, and consequently protracted the period of relief; while the master manufacturer, being restricted from the payment of less than the regulation prices for labour, was without the temptation to add to his stock of goods, in the hope of a revived demand, which, under similar circumstances, has often lightened the evil to the labouring artisan.

In its general operation, this compulsory regulation of wages was fatally opposed to the adoption of improvements depending on the use of machinery. The weaver was paid a certain price for the performance of labour with his own implements. However much it would have abridged that labour could he have borrowed the aid of machinery, the means for this were never within his reach. In other branches of manufacture, processes have been importantly simplified by the invention of artisans, who always find in their employers every willingness to incur the necessary risk, and to assist them by making the requisite experiments, knowing that they must share in the consequent advantage. The greatest improvement that has yet been made in figured silk weaving was the production of an operative weaver. Had this invention been introduced in England during the existence of the local act, the important branch of manufacture just mentioned must have been abandoned in Spitalfields. The weavers could not by any means have accomplished the purchase of the machine; and as the masters must have paid the same price in either case, they, assuredly, would not have put themselves to expense in the matter. The consequence in such case would have been, that the country manufacturer, being able to make such arrangements with the weavers in his employ as were called for by the alteration of circumstances, would have undersold the London trader, and monopolised the business. That this is not a fanciful or doubtful view is proved by the fact; for since the repeal of this restrictive enactment, the master manufacturers have, at their own charge, actually furnished improved machinery for the use of the operative weavers, and have participated with them in the resulting benefits.

During the continuance of these acts, there was, in the Spitalfields district, no medium between the full regulation prices and the total absence of employment. It does not appear that wages were ever fixed so high as to enable the weavers to save much of their earnings, when even they were fully employed. Had it been otherwise, the improvidence which usually characterises the uneducated poor, would have prevented their reaping advantage from the circumstance; and it must surely be better, on every account, that a man so circumstanced should, in seasons of dulness, work for even a scanty pittance rather than that he should be wholly incapacitated from contributing to the support of himself and his family.

The district of Spitalfields has, it is true, enjoyed a very material advantage over every other place in the kingdom where the silk manufacture has been established. Its proximity to the great mart for consumption, and the ever-varying demands of fashion in the metropolis, have given constant employment to a certain extent, without much reference to the cost of production; but as this source of demand must necessarily be far below the power of supplying it, superior artisans alone have obtained employment by reason of it, and the relief has consequently been far more partial in its effects than, under other circumstances, it might have proved. Some intelligent manufacturers, who advocated the regulation system, argued, that since, on account of the duties on the raw material and the cost of its transport, England could not compete with the Continent, but must have its market limited strictly to its own wants, and those of its immediate dependencies, it was of little importance whether wages were high or low; for if the prices had been reduced by the whole amount of wages, the actual consumption would not have been extended by it; and, on the other hand, if the price of labour were left without restriction, the selfish dispositions of many master manufacturers would lead them to take every unfair advantage of the journeymen weavers, who would thence be driven, habitually, to the resource of the poor-rates, and thus, deprived of their feelings of honest independence, would sink in the scale of society, with morals deteriorated equally with their outward condition. Allowing to this argument all the force and philanthropy which can be demanded, it must be admitted that to be effectual and equitable the acts should have embraced the regulation of wages in all the silk manufactories throughout the kingdom; and the proof of this is afforded by the fact, which has never been disputed by even the warmest advocates for regulation, that the operation of the Spitalfields act occasioned the removal of many branches of the silk trade from London to districts in the country beyond the limits of that restrictive enactment.

Notwithstanding the contrary tendency of this measure, the trade of Spitalfields has, accompanied, it is true, by some distressing fluctuations, gone on increasing. If one branch of manufacture was attracted elsewhere by the greater cheapness of labour, others were called into existence; and London, from the cause before explained, has always been, and will continue to be, the nursery for the infant branches of the manufacture.

The abolition of duties on the importation of raw silk in the year 1824, and the total alteration in our system of restrictions which followed that measure, have tended, by their happy consequences, greatly to enlighten the public mind upon the subject of commercial prohibitions. The silk trade of England, which, in the opinions of many experienced persons, existed only through the exclusion of the manufactures of other countries, has received new life from the breaking down of the barriers raised for its protection.

During the ferment which accompanied this revolution in our commercial policy, and when the minds of some were filled with apprehensions, preparations were made by the great majority of the manufacturers for a most important extension of our productive powers. The capital set free by the abolition of the duty was not suffered to lie dormant, but was employed by them in accomplishing this extension. The number of throwing mills in the country was increased from 175 to 266, and of spindles from 780,000 to 1,180,000: the looms employed in Spitalfields amounted in number to 17,000; and so great was the demand for thrown silk, that although, for the moment, the foreign supply was increased by nearly fifty per cent., and the number of mills was augmented in the degree just mentioned, still the weavers were frequently obliged to wait during months for the full execution of their orders by the throwsters.

In 1824 and 1825 all was excitement and overproduction in every branch of our national commerce and industry, and then followed the dreadful revulsion which will live so long in the memories of our merchants and manufacturers. In the month of July, 1826, the admission of foreign silk manufactured goods was to commence, under a duty equivalent to about thirty per cent. on their value; and during the season of depression, which is ever unfavourable to the formation of sound opinion, a clamour was raised against this relaxation, the prospect of which was alleged as the main cause of the weavers' distress. Happily, however, for the best interests of the country, its commercial policy was swayed by one, who, like the celebrated Turgot, had the ability to see, and the firmness to uphold, measures of wisdom and of prudence, in opposition to the clamour of his opponents. Among these, it is to be presumed, there is scarcely to be found one who does not now acknowledge, with thankfulness and admiration, the justness of his views, which then passed for visionary speculations, and the constancy of his mind, which they were then prone to stigmatise as obstinacy.

The law permitting the importation of foreign manufactured silks was allowed to come into operation, and has done more for the developement of skill in the English weavers, than might have been produced during ages of a dull and enervating monopoly. The boast of former days, so often made, and with so little foundation, is now fully realised, and the fabrics of our artisans vie successfully, in excellence, with the most beautiful performances of the continental weavers, so that many of the productions of our looms are sought and viewed with preference in countries whose superior advantages were held up to the English weavers as causes for apprehension amounting to dismay.

A short time previous to the full operation of the law of 1824, a silk manufacturer of high respectability and skill quitted France and formed an establishment in London; this became an immediate object of jealousy to the English weavers, who complained that it was used principally as a cover for an illicit introduction of the then contraband fabrics of France. This accusation was met, on the part of the foreigner, with a demand for the strictest investigation, and the contents of his warehouse were subjected to a severe scrutiny. When, as the result of this inspection, a seizure had been made of thirty-seven pieces of goods, which, in the estimation of the most competent judges from Spitalfields, were unquestionably of foreign make, the individual English weavers, whose skill had produced the articles, were brought forward to disprove the allegation.

Is any further argument required, to prove the accuracy of judgment that dictated this departure from a system of burthensome duties and restrictions, which, while other branches of our manufacturing industry had been advancing with giant strides in the race of improvement, kept the silk trade alone in a state of listless inactivity? If so, it will be found in the evidence of custom-house returns.

Were any individual year singled out as an example of this fact, it might be considered as inconclusive, and perhaps unfair. The period immediately following the alteration of a system is not one wherein the permanent effects of that alteration can be rationally considered; and the trading of the first year after the abolition of the heavy duties might have been thereby stimulated to an unnatural extent; but this objection cannot apply, if the period of comparison be spread over a space of five years, for in that time, any amount of undue excitation and over-trading would have found its correction in following years of consequent depression.

Contrasting, therefore, the five years immediately preceding the alteration of system, with an equal period following that measure, we find, that in the year

		lbs.	lbs.
1819, the importation was, —	raw silk,	1,480,990	
	thrown,	301,588	
			1,782,578
1820, - -	raw silk,	1,702,416	
	thrown,	309,953	
			2,012,369
1821, - -	raw silk,	1,940,516	
	thrown,	350,209	
			2,290,725
1822, - -	raw silk,	2,037,415	
	thrown,	370,273	
			2,407,688
1823, - -	raw silk,	2,085,972	
	thrown,	346,314	
			2,432,286
Making a total of - - - in the last five years of prohibition.			10,925,646

In 1824, the first year of low duties, the importation was —

		lbs.	lbs.
	raw silk,	3,540,910	
	thrown,	452,469	
			3,993,379
1825, - -	raw silk,	3,030,756	
	thrown,	556,642	
			3,587,393
1826, - -	raw silk,	1,955,042	
	thrown,	289,325	
			2,244,367

		lbs.	lbs.
1827,	raw silk,	3,755,242	
	thrown,	454,015	
			4,209,257
1828,	raw silk,	4,162,550	
	thrown,	385,262	
			4,547,812
Making a total of			18,582,213

in the first five years of relaxation; exhibiting an increase of no less than seventy per cent. in the annual consumption of the country.

It has been stated, that when, in the year 1824, the legislature determined upon altering the system by which the silk manufacture was conducted; and legalised, prospectively, the importation of foreign silk goods under a rate of duty which was judged to afford sufficient protection to the home manufacturer, concession was so far made to the apprehensions of this class as to defer the operation of that portion of the law for two years, which interval was asserted to be requisite in order to enable the English weaver to prepare himself, by the production of goods fitted for that object, for the formidable competition in which he was about to engage.

That men occupied in any particular calling should by want of judgment and information be betrayed into measures against their interest, is not extraordinary; prevented by the circumstances wherein they are placed from taking more than a partial view of the subject, they are prone to fill up the prospect with chimeras, and shrink with apprehension from phantoms of their own creation: but it is, on the other hand, truly surprising that others, whose faculties had no such influences to mislead them, should yet have failed on this occasion to perceive that the same interval which was granted to the home manufacturer was equally enjoyed by the foreigner, during which he might accumulate a large stock of goods ready to be poured into our markets at the moment of the act coming into operation. This, in fact, was the course pursued by the French; and when the near prospect of this inundation had created a new subject for alarm in the minds of our own manufacturers, an expedient was adopted as a remedy, which was equally at variance with liberality as it affected our neighbours, and contrary to sound policy as it regarded ourselves.

The French weavers had always been accustomed to make their silk goods of one particular length; and with the design of rendering these their preparatory labours unavailing, a law was passed by parliament, whereby it was, among other things, enacted, that only silks of certain declared lengths, different altogether from those hitherto made and used in France, should be admitted; disqualifying thus from legal importation all goods then made with a view to the English market. The consequences of this enactment were, that the French manufacturers set instantly to work to make fresh goods of the prescribed length for English consumption, while the prohibited pieces, falling as instantly in value, were purchased by the illicit trader, and smuggled into this country; their low price causing them more effectually to interfere with our domestic productions.*

It had never been found practicable, under the system of exclusion, to prevent the prosecution of this contraband trade in silk goods. French silks and ribands, from their then superiority to those of our own production, had always been preferably sought by our countrywomen: and to such an extent was this trade systematised, that silk goods of all descriptions might be purchased in France; the seller taking upon himself to guarantee their safe delivery in England, at the very house of the purchaser, and relieving himself in turn from the chances of loss, by insuring the amount at offices established for that purpose, and where policies were granted with as much facility against loss by seizure, as for protection against the elements—the premium varying, of course, according as a greater or less degree of vigilance was found to be exerted by our revenue officers.†

With the knowledge of these practices full in their minds, and aware, from experience, of the impossibility of effectually stopping them, the admission of foreign silks was no longer matter of choice with our government; and the only question for consideration was, how to draw from this branch of commerce the highest amount of revenue. It was evident, that, by fixing the rate of duty too high, the French smuggler and the insurance offices would continue their successful competitorship; and the government was sorely perplexed by the certainty of this on the one hand, and by the overcharged fears of our manufacturers on the other, in their endeavours to effect an accurate adjustment of the question.

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* Note M. † Note N.

Independently of the enormous expense attending establishments for the prevention of illicit trading, — and this pecuniary evil is one of no inconsiderable magnitude, — governments would appear to be under a moral obligation to remove, as far as possible, all incentives to the commission of the crime of smuggling. The opinion, that infractions of revenue laws are, at most, but venial offences, is one very generally held among the uneducated; and, judging from the encouragement afforded to smugglers, the idea is not by any means confined to that class: if, however, crimes are to be estimated with reference to their probable influence upon the general well-being of society, the smuggler's calling can by no means be considered harmless; since, by familiarising him with violations of the law in one of its codes or branches, it tends to break down the barriers which should restrain him in regard to moral observances generally; and, in truth, a laxity of practice in this so-esteemed venial fault leads from one step to another, through various gradations of crime, until the mind and heart become at length wholly corrupt and brutalised, and murders the most cruel and atrocious, perpetrated in defending the objects of their criminal traffic, are the melancholy consequences.

While the necessity exists for the imposition of duties, it is hardly to be hoped that smuggling can altogether cease; nor, indeed, does it appear possible for any government, however strong and vigilant, effectually to counteract the diligence and activity of those who draw their subsistence from illicit trading: but that much may be done in lessening the evil, by a judicious adjustment of the scale of duties, is rendered evident by the fact, that since the duty on foreign silk goods has been placed on its present footing, it has become comparatively indifferent to the trader, as a question of profit, whether to pass them regularly through the custom-house, or to insure the value against the chances of seizure; the demands of the smugglers and the insurance offices being nearly equal to those of the government. From this it may fairly be inferred, that the amount imported of smuggled silk goods has been greatly diminished: many persons who would have little or no objection to these importations on the score of their illegality, would yet be restrained from embarking in adventures attended with risk of loss, and would prefer to follow the course of virtuous and good citizens from the moment that an opposite line of conduct ceased to be accompanied by extra profits!

The inducements for smuggling afforded by the imposition of exorbitant duties, although strong, are yet by no means so great as where the importation of an article of commerce is altogether prohibited. This affords the greatest encouragement to the illicit trader; since it directly enlists among the ranks of his customers that numerous and influential class of persons which estimates the value of things according to their scarcity and difficulty of attainment, giving to the interdicted article a factitious superiority which disappears at the first breath that destroys the prohibition. Is it not notorious, that during the whole period of their interdiction, French silks and ribands were to be seen in every society that laid claim to the distinction of fashion; and that India silk handkerchiefs were to be found universally in the pockets of men of the upper and middle classes, and even adorning the necks of the labourer and the artisan?

Prohibitory laws seem to be considered unjust and arbitrary interferences with the natural liberty of man, and to carry with them none of the sanctions of morality: they are broken, consequently, without hesitation, by persons who would yet scruple to withhold clandestinely the payment of any rate of duty that might be imposed.*

It is not asserted that the introduction of foreign manufactured silk goods should be at once permitted free from the imposition of any duty. It has been contended, that some protection is called for, because the foreign manufacturer is in the country of production, while the cost of the raw material is enhanced to us by the expense of carriage; an argument scarcely deserving of any consideration, since the conveyance of manufactured articles must be at the least as expensive as that of the raw material; and, besides, so long as France continues to draw any part of her supplies from abroad, the price of the whole of the silk manufactured in that country must be governed by the cost of the portion which is imported. But while the expense of living is higher in Great Britain than it is in those countries whose political and financial circumstances place them in a less artificial state, the wages of labour ought to be and will be higher in something like an equal ratio. Greater comforts are needed by the English artisans, in consequence of the less favourable nature of our climate; and if, after taking all these circumstances into calculation, it is yet found that the labouring classes here are not all sunk so deeply into the abyss of poverty and wretchedness as those of some neighbouring states may be, it will not thence be argued that their situation is too favourable, and that the principle of buying in the cheapest market should, as is sometimes insisted on, be carried to so extreme a length as would lower them to the same miserable level, and reduce them to the procurement of bare subsistence.* There is too much reason for believing that this is, in many of our manufacturing districts, the unhappy condition of our labouring artisans; and occurring, as it generally does, with reference to branches of industry wherein we have no foreign rival to contend against, legislative protection would be unavailing; but so long as, by the imposition of a moderate duty upon importation, the real comfort of a large and deserving class of our fellow countrymen can be maintained, there are surely few, if any, who would object to the impost: but to carry this protection beyond the limit here pointed out, would be injurious towards other classes of the community, without insuring, in any adequate degree, the particular benefit that was intended.

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* Note P.

In regard to the silk manufacture, the duty required in order to maintain the English weavers in the same relative position which they already hold with those of France, is very much lower than, without enquiry, many would be led to imagine. On consulting a comparative statement drawn up by an experienced silk manufacturer of London, it appears that, independent of duties, which are purposely kept out of view, the entire difference in the cost of one pound of the best thrown silk, when manufactured into sixteen yards of Gros-de-Naples, is five shillings and sixpence, or barely fourteen and a half per cent. * : of this amount of difference, it will be seen that

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* Comparative estimate of the cost of one pound of silk when manufactured into Gros-de-Naples at Lyons and London respectively.

In Lyons.		£	s.	d.
Price current of organzine 25s. per lb., 8 ounces of which - - - - -		0	12	6
Ditto of tram 22s. 6d. per lb, 8 ounces of which -		0	11	3
Dyeing warp and shoot † -		0	0	11
		1	4	8
Add 4 ounces for loss in dyeing and waste, to make 16 ounces when manufactured - - - -		0	6	2
		1	10	10
Winding and warping 1s. 3d.				
Weaving 16 yds, reckoning 1 oz to the yard, at 4½d per yd.	6 0	0	7	3
		1	18	1
Difference in favour of the French manufacturer -		0	5	6
		2	3	7

In London.	£	s.	d.	£	s.	d.
Price current of fine tram silk in Italy -	1	2	6			
Export duty and expenses -	0	0	6½			
Carriage to Calais	0	0	3½			
per lb.	1	2	4			
Eight ounces of which -				0	11	2
Price current of fine organzine in Piedmont -	1	3	0			
Duty and expenses - -	0	0	9¾			
Carriage to Calais	0	0	3¼			
per lb.	1	4	1			
Eight ounces of which -				0	12	0½
Dyeing warp and shoot, black and ordinary colours, soft and souple -				0	1	6
				1	4	8½
Add 4 ounces for loss in dyeing and waste, to make 16 ounces when manufactured - -				0	6	2
				1	10	10½
Winding and warping		2	0½			
Weaving 16 yards, reckoning 1 ounce to the yard, at 8d. per yard - -		10	8			
				0	12	8½
				2	3	7

the sum of four shillings and eight pence, or twelve and a quarter per cent. is made up of the higher wages paid in London for the actual weaving of the fabric; the higher charge of the dyer amounts to seven pence; and the small remaining sum is divided among the persons employed in warping and winding the silk.

This comparison is made on the supposition that Italian thrown silk is used in both cases; and, as already mentioned, excluding the amount of duty payable on importation to this country. This duty is after the rate of three shillings and sixpence per pound; but the importer is furnished, when it is paid, with a *transferable* title to draw back the amount upon the exportation of an equivalent weight of wrought silk; of this title he, of course, avails himself, either personally or by proxy, and it would, consequently, be improper to consider the duty in forming this comparative estimate.

It has been well remarked by the baron Charles Dupin, who, from his diligent researches into all subjects connected with commercial questions, is entitled to have his opinions received with a high degree of respect and confidence, that in the most considerable branches of manufacture, the most decided superiority has been obtained by people with whom the price of labour is dearer than with their rivals. He instances the cotton manufactures of England, which are furnished better and cheaper than by any other people of Europe, although labour is dearer in Great Britain than in any other country of our hemisphere. He then brings forward the manufacture of linens, in which the Dutch and Belgians surpass and sell cheaper than the Bretons, although the price of labour is dearer in Belgium and Holland than it is in Britany: and he further shows, that in the production of fine woollens, France surpasses and undersells Spain, although the price of labour in the former is higher than in the latter kingdom.*

The freight and expenses from Calais are not included in the above statement: the cost of transporting manufactured goods from Lyons to London, which is greater, must, in such case, have been added to the price of the Lyons manufacture.

* Note 9.

The superiority in these instances, which is sufficiently striking, Dupin rather refers to higher attainments of mechanical skill, and greater degrees of commercial knowledge and enterprise.

Is it then expecting too much to hope that, by continuing to apply to the silk manufacture the same amount of skill and enterprise which have served to gain for us a pre-eminence so decided in our cotton fabrics, we may shortly become sufficiently expert to bring the produce of our silk-looms, unprotected by discriminating duties, into successful competition with those of France, and to meet the latter in the fair spirit of rivalry in those foreign markets which have hitherto been virtually closed against us?

It does not require any very deep research into the subject to discover that the silk manufacture of England has received, in all its branches, a most important impetus from the alteration of system which began in the year 1824. For a time this impulsion showed itself only in the augmented quantity of raw material submitted to the labours of the weaver; but from the period when wrought silks of foreign manufacture were admitted legally into competition with those of domestic fabric, our artisans have proved how capable they are of evincing as great a degree of ingenuity in this branch, as England has so long been accustomed to display in other manufactures. The once existing disparity in quality between goods of French and English make has, with some very unimportant exceptions, not merely disappeared, but actually ranged itself on the side of the British artisan; and as regards the cost of conversion, if the spur of competition has not urged us forward in an equal ratio, it has yet done much,—more indeed than, without experience of the fact, was once thought possible. Improvements in the machinery employed, both in throwing and weaving, have led to this gratifying result—that the cost of the processes of organzining silk has fallen to little more than one half what it formerly amounted to, and a much greater proportional abatement has occurred in figure weaving.

Can it be pretended, that these advantages would have ensued under the old enervating system of high duties and prohibitions? and does it not seem desirable that the legislature should follow up this result, removing by degrees, but as rapidly as consists with safety, the remaining mounds and defences against foreign interference? Until the arrival of a state of things under which these may all be abolished, England can hardly hope to employ her silk-looms in the service of foreign countries; but if it be desirable,—and who can dispute that it is so?—to export our silks in company with our cotton manufactures, would it not, by exciting emulation, accelerate that event, if it were known that every coming year some abatement would be made from the scale of protecting duties, until they should be wholly abolished? If the foregoing statements, carefully as they have been collected and examined, should be thought entitled to credit, the duty at present levied upon foreign manufactured silk goods is, in most cases, double what is needed to place the productions of France upon an equality with our own; and if this disproportion has arisen, as is believed to be the fact, since the arrangement of the rates, and the opening of our markets to foreign manufactured silks, in the year 1826, does it not offer reasons sufficient for revision and abatement, while it holds out the certain prospect of further and progressive opportunities for reduction, until, under their abolition, the British silk manufacturers will become, first, undisputed masters of our home markets, and next artificers for others?

The duties now chargeable upon the importation of raw, thrown, and manufactured silks, as well as the drawback recoverable on re-exportation, may be found in the following table:—

	£	s.	d.
Knubs, or husks of silk, and waste of silk, the cwt.	0	1	0
Raw silk, the lb. - - - - -	0	0	1

	£	s.	d.
Thrown silk, not dyed, namely—			
Singles, the lb.	0	1	6
Tram, the lb.	0	2	0
Organzine and crape silk, the lb.	0	3	6
Thrown silk, dyed, namely—			
Singles, or tram, the lb.	0	3	0
Organzine, or crape silk, the lb.	0	5	2
Manufactures of silk, or of silk mixed with any other material, namely—			
Silk or satin, plain, the lb.	0	11	0
or, and at the option of the officers of the customs, for every 100*l.* of the value	25	0	0
Silk or satin, figured or brocaded, the lb.	0	15	0
or, and at the option of the officers of the customs, for every 100*l.* of the value	30	0	0
Gauze, plain, the lb.	0	17	0
or, and at the option of the officers of the customs, for every 100*l.* of the value	30	0	0
Gauze, striped, figured, or brocaded, the lb.	1	7	6
or, and at the option of the officers of the customs, for every 100*l.* of the value	30	0	0
Velvet, plain, the lb.	1	2	0
or, and at the option of the officers of the customs, for every 100*l.* of the value	30	0	0
Velvet, figured, the lb.	1	7	6
or, and at the option of the officers of the customs, for every 100*l.* of the value	30	0	0
Ribands, embossed or figured with velvet, the lb.	0	17	0
or, and at the option of the officers of the customs, for every 100*l.* of the value	30	0	0
And further, if mixed with gold, silver, or other metal, in addition to the above rates, when the duty is not charged according to the value	0	10	0
Fancy silk, net or tricot, the lb.	1	4	0
Plain silk lace, or net, called tulle, the square yard	0	1	4
Manufactures of silk, or of silk mixed with any other material, the produce of and imported from places within the limits of the East India company's charter, for every 100*l.* of the value	20	0	0
Millinery of silk, or of which the greater part of the material is of silk, namely—			
Turbans or caps, each	0	15	0
Hats or bonnets, each	1	5	0
Dresses, each	2	10	0
or, and at the option of the officers of the customs, for every 100*l.* of the value	40	0	0

	s.	d.
Manufactures of silk, or of silk and any other material, not particularly enumerated, or otherwise charged with duty, for every 100*l.* of the value -	30	0 0
Articles of manufacture of silk, or of silk and any other material, wholly or part made up, not particularly enumerated, or otherwise charged with duty, for every 100*l.* of the value -	30	0 0

Drawback is allowed, as under, on the exportation of silk manufactured goods, its gross amount being limited to the amount of duties previously paid on foreign thrown silk, as has already been explained:—

	£	s.	d.
For every pound weight of manufactured goods, composed of silk only - - -	0	3	6
For every pound weight of silk and cotton mixed, whereof one half at the least shall be silk -	0	1	2
For every pound weight of silk and worsted mixed, whereof one half at the least shall be silk -	0	0	7

To throw additional obstacles in the way of smuggling, the importation of foreign wrought silk goods is restricted to the ports of London, Dublin, and Dover; and can only be effected in vessels of at least seventy tons burthen, except when brought direct from Calais to Dover, for which trade, vessels that are of only sixty tons burthen may be licensed by the lords of the treasury, or by the commissioners of his majesty's customs.

PART II.

ON THE CULTURE OF SILK.

CHAP. I.

ON THE CULTURE OF THE MULBERRY TREE.

DIFFERENT SPECIES OF THE MULBERRY TREE. — COMPARATIVE QUALITIES AS FOOD FOR SILKWORMS. — SOIL AND SITUATION MOST FAVOURABLE FOR ITS GROWTH. — MANNER OF RAISING IT. — FROM SEED. — FROM CUTTINGS. — INGRAFTING. — NUMBER OF BROODS OF SILKWORMS ANNUALLY REARED IN DIFFERENT COUNTRIES. — NUTRITIVE QUALITIES OF THE MULBERRY LEAF. — PRESERVATION OF LEAVES. — QUANTITY OF LEAVES THAT MAY BE ANNUALLY TAKEN FROM ONE TREE. — THE MULBERRY LEAF SACRED TO THE SILKWORM.

THE first object of attention, preparatory to any extensive attempt for the production of silk, must be the culture of the mulberry tree, the leaves of which form the sole subsistence of the silkworm.

This tree, the *morus* of botanists, is a genus of the tetrandria order, belonging to the monœcia class of plants. Linnæus enumerates seven distinct species of the mulberry tree.

The Nigra, or black-fruited species, is well known in this country, and much prized for the fruit which it so abundantly bears. Any particular description of it here would be superfluous.

The Alba, or white-fruited mulberry, differs from the nigra in having its stem straighter, and its bark smoother and of a lighter colour. Its leaves are likewise smoother, thinner, much smaller, and of a lighter green. The fruit, which is of a pale grey colour, is small, of a vapid sweetness, and of no value.

The Rubra, or red Virginia mulberry tree, differs but little from the alba, except in the red colour of its fruit.

The Tartarica, or Tartarian species, abounds on the banks of the Volga and the Tanaïs.

The Papyfera, or paper mulberry, differs from the other species in having palmated leaves. From the bark of its branches the Japanese prepare their paper. Its leaves are also used as food for the silkworm, for which purpose the tree is now successfully cultivated in France.*

The two remaining species, the Tinctoria and Indica, are not used for the nourishment of the silkworm.†

The mulberry tree is hardy, of quick growth, and easily naturalised in all climates. The black species has always been cultivated for its fruit in Europe. The white sort comes from India, whence it has been introduced into all those western countries which have attempted the culture of silk.‡

The respective qualities of the different species, as connected with the silkworm, cannot be better pointed out than by observing, that if leaves of the white, the red, and the black mulberry be given at the same time to the insect, it will eat first the white, next the red, and lastly the black, in the order of the tenderness of the leaves. The Tartarian seems to hold as high a place in its esteem as either the red or black kind: all, however, give place to the white, which, as it came originally from China, would appear to be its most natural food.

Most writers on the subject affirm that the white mulberry is always used in China, while some few assert that the Chinese now feed their silkworms on the Tartarian species.

The white sort is generally planted for this purpose, in Europe, its leaves being more eagerly desired by the worms. The trees of this species likewise possess the advantage of coming into leaf a fortnight earlier than the black, for which reason the eggs may be hatched earlier in the spring, and the cares of rearing the insects are not prolonged too far into the hottest season. The white mulberry tree is likewise of quicker growth, is not so much injured by the constant plucking of its leaves, nor is it, like the black, incommoded by a great quantity of fruit. The best reason, however, if it be correct, that has been given for preferring it, is, that the silk of worms which feed upon its leaves is finer than where other kinds are substituted. Count Dandolo has, indeed, found, that the quality of the filament does not solely depend upon the food of the insect, but is also influenced by the degree of temperature in which it is reared.

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* Note R. † Note S. ‡ Note T.

In cold climates, the black thrives better than the white mulberry. It likewise bears double the quantity of leaves suitable for food.* In Persia the silkworm is nourished altogether by leaves of the black species. In Granada, where silk of excellent quality is produced, the same system is followed. Swinburne, who travelled in Calabria in 1784, relates that the red species was there generally preferred, because the leaves, not appearing until ten or fourteen days later than those of the white mulberry, are therefore less subject to injury by frost. This reason for its preference is in other climates assigned as the cause of its rejection.

The roots of the mulberry tree strike very deep into the ground, so that the surface not being impoverished as it is by many trees, whose roots are found more in the upper soil, other kinds of cultivation may be prosecuted around it. Neither its shade, nor the dropping of rain from its leaves, is considered prejudicial to plants growing beneath.

Moist lands in valleys and near rivers induce a very rapid growth in the trees; but their leaves contain, in such situations, too much watery matter, and, though eaten voraciously, are hurtful to the worms from their comparative want of nourishment. The labours of the insects are also delayed, and the quality of their produce injured by the weakneſs of constitution resulting from this cause.

* Note U.

Trees in dry soils give fewer leaves, but any deficiency in their quantity is amply compensated by the greater nutriment which they afford, and, as a necessary consequence, by the superior quality of the silk produced.

It is remarked by Mayet, that the quality of the silk depends upon that of the mulberry leaves consumed, "which are then to be considered as being only a mine worked by the worms; and this mine is more or less proper to furnish the fine substance, according to the soil and climate."

The mulberry tree is readily raised, either by cuttings, by layers, or by seed. In countries where the seed must be saved until the favourable season for sowing it shall come round, the process is both troublesome and difficult. Pullein, who wrote in the year 1758, gives very elaborate directions, which he considers necessary for properly saving and preparing the seed. In climates where this delay in sowing is not necessary, the operation is more simple. The plan pursued in France is curious: it is thus described: — "Take the ripe berries when they are full of juice and seeds. Next take a rough horse-hair line, or rope such as we dry linen on, and with a good handful of ripe mulberries, run your hand along the line, bruising the berries and mashing them as much as possible as your hand runs along, so that the pulp and seed of the berries may adhere in great abundance to the rope or hair line. Next dig a trench in the ground where you wish to plant them, much like what is practised in kitchen gardens in England for crops of various kinds. Next cut the rope or hair line into lengths, according to the length of the trench you think fit to make, and plunge the line full of mashed berries into the trench; then cover it well over with earth, always remembering afterwards to water it well, which is essential to success. The seeds of the berries thus sown will grow, and soon shoot out suckers, which will bear young leaves, which are the best food for the silkworm." The facility and rapidity with which young leaves may by this means be produced, is evident; for as many rows of trenches can thus be filled as can be wished; and it can never be necessary to have mulberry trees higher than our raspberry, currant, or gooseberry bushes. Whenever they get beyond that, they lose their value; and if these branches succeed, you may have a supply coming fresh up day after day, or any quantity you please."

Snails and slugs are found to be very destructive to the young mulberry shoots, committing great devastations in a short period. In moist seasons a whole nursery is sometimes threatened by them with ruin. To protect the tender plant from this evil, it is recommended to surround the beds or trenches with dry soot or ashes, sprinkling it afresh after rain. This protection might be advantageously adopted with other plantations, as slugs will not pass over such a fence, especially while it is dry.

In England, and countries of similar temperature, seedlings will not attain a greater height than three inches in the first year. In warmer climates their growth is much more rapid; so that in some parts of India large quantities of seed are sown, whose crops are mowed down in the ensuing season as food for silkworms. Sprouts again spring forth from the roots the same year, and are used for a second brood. The silk produced by worms fed on these tender shoots is supposed to be readily distinguishable, by its superiority over that produced when the insect is fed on the leaf of the full grown mulberry tree.

Plants which are raised from seed require transplantation at the end of the third year, to induce the spreading of the root. Without this removal they would acquire only one root, like a pivot, and would be liable to various casualties on that account. Some cultivators believe that it assists this branching out of roots, if the plants are cut even with the ground at the end of the second year.

The most easy and expeditious way of raising mulberry trees is from cuttings. Although as great a number cannot so readily be raised in this manner as from seed, there is a great advantage in point of strength as well as in the rapidity of their growth. This method of propagation is much more successful in moist and temperate climes than in such as are exposed to the arid heat of the lower latitudes. Cuttings will put forth shoots of about five or six inches in length during the first summer, and will, at the same time, be providing themselves with roots. If they have put forth shoots, and preserve their leaves until the autumn, the plants will generally succeed: any which have failed to do so must be replaced by other cuttings In the course of the ensuing spring and summer, if carefully watered, the shoots will frequently attain the length of eighteen inches. In the autumn following the beds must be thinned, and the redundant saplings planted out.

Mulberry plantations which are formed in France and Italy consist of large standard trees. This is a very inconvenient method: as the leaves cannot be gathered but by the aid of ladders, and by climbing among the branches. In this way the trees may sustain much injury; besides which a great deal of time is unnecessarily wasted in reaching the leaves, which then are seldom gathered with regularity.

Du Halde, in his history of China, relates that the Chinese are particular so to place and to prune their mulberry trees, that the leaves may be gathered in the easiest manner, and without risk of damage to the trees. These are, with this view, cut in a hollow form, without any intersecting branches in the middle; so that a person going round the tree may gather all the outside leaves, and afterwards, by standing withinside, and merely turning round to the different parts, may pluck the leaves growing within. The trees are not allowed to grow to any great height; so that each tree forms a sort of round hedge, and may be reached throughout without climbing on its branches.

Pullein gives very ample directions for forming and rearing plantations of mulberry trees. His work has been considered one of high authority, and may be profitably consulted by any who require more minute information than it is desirable to furnish in this volume.

Ingrafting is considered to be one of the surest methods of obtaining nutritious leaves from mulberry trees. Monsieur Bourgeois observes, that mulberries ingrafted on wild stocks, when the graft is chosen from a good kind, such as the rose-leaved or the Spanish mulberry, produce leaves which are much more beautiful, and of much better quality for feeding silkworms, than such as are ingrafted on the common wild stock. The same observation has been made by Monsieur Thomé, whose authority is of the greatest weight in whatever relates to the rearing of silkworms, to which object he devoted forty years of his life.

Although ingrafted mulberries certainly produce a greater number of leaves than the wild trees, and these leaves are thought to contain more nourishment to the insect, yet the wild tree has an advantage over that which is ingrafted, in its superior longevity. The former has been known to exist for two centuries; while the increased quantity of leaves produced by ingrafting causes a premature dissipation of the sap of the tree, and accelerates its decay. Monsieur Pomier, in a treatise which he has written upon the subject, recommends that white should be ingrafted on black mulberries; and the reason urged for the adoption of this plan is, that the white species commonly decays first in the root, while the black is not subject to any disease.

The more attention that is bestowed upon the tree, by dressing and pruning the overgrown branches, the greater abundance of good leaves will it furnish. It is very hurtful to the trees to strip them when too young, because leaves are organs which fulfil important functions in plants; contributing greatly to their nutrition by absorbing vessels, which imbibe moisture from the air. The leaves may be safely gathered after the fifth year. Mulberry trees are so plenteously stored with sap, that they sometimes renew their leaves twice or thrice in the same year. When the winter has been mild, they put forth leaves very early; but it is always dangerous, in any but hot climates, to accelerate the hatching of the worms in expectation of this event; for no leaves should be depended on till the beginning of May, as those which appear prior to this period are exposed to destruction from frost.

According to Monsieur Nollet, the inhabitants of Tuscany, especially in the neighbourhood of Florence, do not cultivate half as many mulberry trees as the Piedmontese, in proportion to the number of silkworms reared and the quantity of silk produced. This economy is realised by causing the worms to be hatched at two separate periods. The first brood is fed on the first leaves of the spring; and when these worms have gone through their progressions, and have produced silk, other eggs are hatched, and the insects are nourished by a second crop of leaves furnished by the same trees. This plan is followed in China, where two crops of silk are obtained in the year; and it has been said that in some other parts of Asia as many as twelve broods of worms are reared in the course of one year. In the Isle of France Monsieur Chazal obtained three generations between the months of December and May; the mulberry tree there, as well as in India, affording fresh leaves through the whole year.

Count Dandolo is of opinion that in Italy it is disadvantageous to obtain more than one crop in each season. He affirms that the mulberry tree cannot bear this constant stripping of its leaves without injury. "All things considered," says he, "I am well persuaded that one of our good crops will be equal in produce to any number that may be gathered elsewhere in a year." It is observed that the quality of the silk obtained in Italy from their second *racolta* is always inferior to that from the first brood of worms.

The Persian cultivators are accustomed, from a motive of economy, to feed silkworms upon boughs of the mulberry tree, instead of using the leaf separately, as is practised in all temperate climates. The leaves, continuing attached to the branches, remain longer fresh, have a better flavour, and are more nutritious, than those separately gathered, and the silkworms feed from the branches with less waste than when the leaves are strewn singly over them.

In estimating the qualities of the mulberry leaf, as regards nutrition, it should be considered as being composed of five different substances. The solid or fibrous, the saccharine, and the resinous substances, water, and colouring matter.

The fibrous substance, water, and colouring matter, cannot be said to contribute towards the nourishment of the silkworm. The saccharine matter is that which sustains the insect, causes its increase in size, and goes to the formation of its animal substance. The resinous substance, according to count Dandolo, is that which, "separating itself gradually from the leaf, and attracted by the animal organisation, accumulates, clears itself, and insensibly fills the two reservoirs or silk vessels. According to the different proportions of the elements which compose the leaf, it follows, that cases may occur in which a greater weight of leaf may yield less that is useful to the silkworm, as well for its nourishment, as with respect to the quantity of silk obtained from the animal."

To complete the developement of the silkworm, the quantity of leaves consumed must bear relation to the nutriment they contain. It is therefore important, that leaves containing the most nutriment should be supplied to the insect, as it is more fatigued and more liable to disease from devouring many leaves, than it would be if an equal quantity of nourishment were supplied by fewer leaves containing more saccharine substance. Again, if this abounds in the leaf, and the resinous substance is not found united with it in sufficient quantity, the worm will, it is true, thrive and grow, but will not produce silk proportionate to its weight.

In some parts of Italy and France, mulberry leaves are commonly sold by weight in the market, and those persons who rear silkworms are often wholly dependent on this source for a supply. Judgment and experience are required in the purchaser, to enable him to make a proper selection of leaves, choosing such as are of a nourishing quality, and rejecting those whose sale would, from their greater weight, be more profitable to the vendor. The interests of the two parties are consequently at variance. In other places, trees are hired for the season; from four to six francs, according to its size and condition, being paid for the hire of each tree. Under equal circumstances, an old mulberry tree always yields better leaves than a young one; and whatever may be the original quality of the tree, as it grows older the leaf will diminish in size, and will so materially improve, that at length it will attain to a very excellent quality.

It is of importance that the age of the leaves should keep pace with that of the worms. The young leaf, being replete with aqueous matter, provides for the great evaporation continually proceeding from the body of the young worm; while the mature leaf contains a larger proportion of solid nutritive matter, better suited to the wants of the insect at its more advanced age. To give old leaves to young worms, or young leaves to old worms, would be alike prejudicial.

The greatest care must be taken to prevent the leaves becoming heated or fermented. The nutritious substance of the leaf is altered and injured by the slightest fermentation, and it becomes too stimulating for the health of the worm. It is also essential that the leaves be given to the insects perfectly dry; contagious and fatal diseases will otherwise ensue.

It is considered that a well cultivated mulberry tree should yield, in each season, about thirty pounds of good leaves. It is not uncommon in the south of France to see large trees which will furnish five times this quantity.

It is said that no insect excepting the silkworm will feed on the mulberry leaf. Pullein tried the speckled hairy caterpillar, which feeds on the nettle, as well as several other kinds of insects, but they all rejected the mulberry leaf for their food. Once, indeed, he discovered upon a mulberry tree a green worm, about an inch long and as thick as an oat straw. He confined it in a box, and fed his prisoner with mulberry leaves. Pullein believes that it was not a native of the tree, but found itself there accidentally when it was taken. During the continued observation of three years, Miss Rhodes never once found an insect upon the leaves used by her. Other fruit trees and vegetables in the same garden were sometimes covered by myriads of insects, while the mulberry tree, surrounded by these ravagers, remained sacred from their depredations. Not even the aphides invade this tree, exclusively devoted to the use of the silkworm.

CHAP. II.

DESCRIPTION OF THE SILKWORM.

VARIOUS CHANGES OF THE WORM. — ITS SMALL DESIRE OF LOCOMOTION. — MANNER OF CASTING ITS EXUVIÆ. — SOMETIMES CANNOT BE FULLY ACCOMPLISHED. — CONSEQUENT DEATH OF THE INSECT. — PROGRESS OF ITS EXISTENCE. — MATERIAL OF WHICH ITS SILK IS FORMED. — MODE OF ITS SECRETION. — MANNER OF SPINNING. — FLOSS SILK. — THE COCOON. — ITS IMPERVIOUSNESS TO MOISTURE. — TRANSFORMATION OF A WORM INTO A CHRYSALIS. — PERIODS IN WHICH ITS VARIOUS PROGRESSIONS ARE EFFECTED IN DIFFERENT CLIMATES. — EFFECTS OF INCREASED TEMPERATURE. — MODES OF ARTIFICIAL HEATING. — COMING FORTH OF THE MOTH. — MANNER OF ITS EXTRICATION. — INCREASE IN WEIGHT AND BULK OF THE SILKWORM. — NUMBER OF EGGS PRODUCED. — LENGTH, ETC. AT DIFFERENT AGES. — SILKWORMS INJURIOUSLY AFFECTED BY CHANGE OF CLIMATE. — VARIETIES OF SILKWORMS. — SMALL WORMS. — LARGE SPECIES. — PRODUCE YIELDED BY THESE.

The silkworm, or bombyx, is a species of caterpillar which, like all other insects of the same class, undergoes a variety of changes during the short period of its life; assuming, in each of three successive transformations, a form wholly dissimilar to that with which it was previously invested.

Among the great variety of caterpillars, the descriptions of which are to be found in the records of natural history, the silkworm occupies a place far above the rest. Not only is our attention called to the examination of its various transformations, by the desire of satisfying our curiosity as entomologists, but our artificial wants incite us likewise to the study of its nature and habits, that we may best and most profitably apply its instinctive industry to our own advantage.

It has been well observed by a writer on this subject, that "there is scarcely any thing among the various wonders which the animal creation affords, more admirable than the variety of changes which the silkworm undergoes; but the curious texture of that silken covering with which it surrounds itself when it arrives at the perfection of its animal life, vastly surpasses what is made by other animals of this class. All the caterpillar kind do, indeed, undergo changes like those of the silkworm, and the beauty of many of them in their butterfly state greatly exceeds it; but the covering which they put on before this change into a fly is poor and mean, when compared to that golden tissue in which the silkworm wraps itself. They, indeed, come forth in a variety of colours, their wings bedropped with gold and scarlet, yet are they but the beings of a summer's day; both their life and beauty quickly vanish, and they leave no remembrance after them; but the silkworm leaves behind it such beautiful, such beneficial monuments, as at once record both the wisdom of their Creator and his bounty to man."*

Silkworms proceed from eggs which are deposited during the summer by a greyish kind of moth, of the genus phalænæ. These eggs are about equal in size to a grain of mustard seed: their colour when first laid is yellow; but in three or four days after, they acquire a bluish cast. In temperate climates, and by using proper precautions, these eggs may be preserved during the winter and spring, without risk of premature hatching. The period of their animation may be accelerated or retarded by artificial means, so as to agree with the time when the natural food of the insect shall appear in sufficient abundance for its support.

The whole of the curious changes and labours which accompany and characterise the life of the silkworm are performed within the space of a very few weeks. This period varies, indeed, according to the climate or temperature in which its life is passed; all its vital functions being quickened, and their duration proportionally abridged, by warmth. With this sole variance, its progressions are alike in all climates, and the same mutations accompany its course.

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* Pullein.

The three successive states of being put on by this insect are, that of the worm or caterpillar, that of the chrysalis or aurelia, and that of the moth. In addition to these more decided transformations, the progress of the silkworm in its caterpillar state is marked by five distinct stages of being.

When first hatched, it appears as a small black worm about a quarter of an inch in length. Its first indication of animation is the desire which it evinces for obtaining food, in search of which, if not immediately supplied, it will exhibit more power of locomotion than characterises it at any other period. So small is the desire of change on the part of these insects, that of the generality it may be said, their own spontaneous will seldom leads them to travel over a greater space than three feet throughout the whole duration of their lives. Even when hungry, the worm still clings to the skeleton of the leaf from which its nourishment was last derived. If, by the continued cravings of its appetite, it should be at length incited to the effort necessary for changing its position, it will sometimes wander as far as the edge of the tray wherein it is confined, and some few have been found sufficiently adventurous to cling to its rim; but the smell of fresh leaves will instantly allure them back. It would add incalculably to the labours and cares of their attendants, if silkworms were endowed with a more rambling disposition. So useful is this peculiarity of their nature, that one is irresistibly tempted to consider it the result of design, and a part of that beautiful system of the fitness of things, which the student of natural history has so many opportunities of contemplating with delight and admiration.

In about eight days from its being hatched, its head becomes perceptibly larger, and the worm is attacked by its first sickness. This lasts for three days; during which time it refuses food, and remains motionless in a kind of lethargy. Some have thought this to be sleep, but the fatal termination which so frequently attends these sicknesses seems to afford a denial to this supposition. The silkworm increases its size so considerably, and in so short a space of time,—its weight being multiplied many thousand fold in the course of one month,—that if only one skin had been assigned to it, which should serve for its whole caterpillar state, this skin would with difficulty have distended itself sufficiently to keep pace with the insect's growth. The economy of nature has therefore admirably provided the embryos of other skins, destined to be successively called into use; and this sickness of the worm, and its disinclination for food, may very probably be occasioned by the pressure of the skin, now become too small for the body which it encases.

At the end of the third day from its first refusal of food, the animal appears, on that account, much wasted in its bodily frame; a circumstance which materially assists in the painful operation of casting its skin: this it now proceeds to accomplish. To facilitate this moulting, a sort of humour is thrown off by the worm, which, spreading between its body and the skin about to be abandoned, lubricates their surfaces, and causes them to separate more readily. The insect also emits from its body silken traces, which, adhering to the spot on which it rests, serve to confine the skin to its then existing position. These preliminary steps seem to call for some considerable exertion, as after them the worm remains quiet for a short space, to recover from its fatigue. It then proceeds, by rubbing its head among the leafy fibres surrounding it, to disencumber itself of the scaly covering. Its next effort is to break through the skin nearest to the head, which, as it is there the smallest, calls for the greatest exertion; and no sooner is this accomplished and the two front legs are disengaged, than the remainder of the body is quickly drawn forth, the skin remaining fastened to the spot in the manner already described.

This moulting is so complete, that not only is the whole covering of the body cast off, but that of the feet, of the entire skull, and even the jaws, including the teeth. These several parts may be discerned by the unassisted eye, but become very apparent when viewed through a magnifying lens of moderate power.

In two or three minutes from the beginning of its efforts the worm is wholly freed, and again puts on the appearance of health and vigour, feeding with recruited appetite upon its leafy banquet. It sometimes happens that the outer skin refuses to detach itself wholly, but breaks and leaves an annular portion adhering to the extremity of its body, from which all the struggles of the insect cannot wholly disengage it. The pressure thus occasioned induces swelling and inflammation in other parts of the body, and, after efforts of greater or less duration, death generally terminates its sufferings.

Worms newly freed from their exuviæ are easily distinguished from others by the pale colour and wrinkled appearance of their new skin. This latter quality, however, soon disappears, through the repletion and growth of the insect, which continues to feed during five days. At this time its length will be increased to half an inch; when it is attacked by a second sickness, followed by a second moulting, the manner of performing which is exactly similar to that already described. Its appetite then again returns, and is indulged during other five days, during which time its length increases to three quarters of an inch: it then undergoes its third sickness and moulting. These being past, in all respects like the former, and five more days of feeding having followed, it is seized by its fourth sickness, and casts its skin for the last time in the caterpillar state. The worm is now about one and a half or two inches long. This last change completed, the silkworm devours its food most voraciously, and increases rapidly in size during ten days.

The silkworm has now attained to its full growth, and is a slender caterpillar from two and a half to three inches in length. The peculiarities of its structure may be better examined now than in its earlier stages. It can readily be seen * that the worm has twelve mem-

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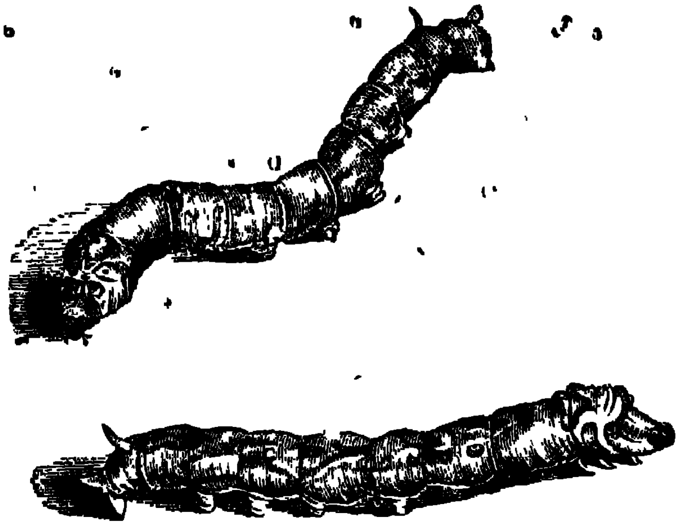
* The scale on which the worms, cocoons, chrysalis, and moths are represented, is two thirds their usual natural size.

branous rings round its body, parallel to each other, and which, answering to the movements of the animal, mutually contract and elongate. It has sixteen legs, in pairs: six in front, which are covered with a sort of shell or scale, are placed under the three first rings, and

Fig. 1.



cannot be either sensibly lengthened, or their position altered. The other ten legs are called holders: these are membranous, flexible, and attached to the body under the rings. These holders are furnished with little hooks, which assist the insect in climbing. The skull is enclosed in a scaly substance, similar to the covering of the first six legs. The jaws are indented or serrated like the teeth of a saw, and their strength is great considering the size of the insect. Its mouth is peculiar, having a vertical instead of a horizontal aperture; and the worm is furnished with eighteen breathing holes, placed at equal distances down the body, nine on each side. Each of these holes is supposed to be the termination of a particular organ of respiration. On each side of the head, near to the mouth, seven small eyes may be discerned. The two broad appearances higher upon the head, which are frequently mistaken for eyes, are bones of the skull. The two apertures through which the worm draws its silky substance are placed just beneath the jaw, and close to each other. These orifices are exceedingly minute.

At the period above mentioned the desire of the worm for food begins to abate: the first symptom of this is the appearance of the leaves nibbled into minute portions, and wasted. It soon after this entirely ceases even to touch the mulberry leaves; appears restless and uneasy; erects its head; and moves about from side to side, with a circular motion, in quest of a place wherein it can commence its labour of spinning. Its colour is now light green, with some mixture of a darker hue. In twenty-four hours from the time of its abstaining from food, the material for forming its silk will be digested in its reservoirs; its green colour will disappear; its body will have acquired a degree of glossiness, and will have become somewhat transparent towards its neck. Before the worm is quite prepared to spin, its body will have acquired greater firmness, and be somewhat lessened in size.

The substance of which the silk is composed is secreted in the form of a fine yellow transparent gum in two separate vessels of slender dimensions, which are wound, as it were, on two spindles in the stomach: if unfolded, these vessels would be about ten inches in length.

When the worm has fixed upon some angle, or hollow place, whose dimensions agree with the size of its intended silken ball or cocoon, it begins its labour by spinning thin and irregular threads, which are intended to support its future dwelling. During the first day, the insect forms upon these a loose structure of an oval shape, which is called floss silk, and within which covering, in the three following days, it forms the firm and consistent yellow ball; the labourer, of course, always remaining on the inside of the sphere which it is forming.*

The silky material, which when drawn out appears to be one thread, is composed of two fibres, extracted through the two orifices before described; and these fibres are brought together by means of two hooks, placed within the silkworm's mouth for the purpose. The worm in spinning rests on its lower extremity throughout the operation, and employs its mouth and front legs in the task of directing and fastening the thread. The filament is not spun in regular concentric circles round the interior surface of the ball, but in spots, going backwards and forwards with a sort of wavy motion. This apparently irregular manner of proceeding is plainly perceptible when the silk is wound off the ball, which does not make more than one or two entire revolutions while ten or twelve yards of silk are being transferred to the reel.

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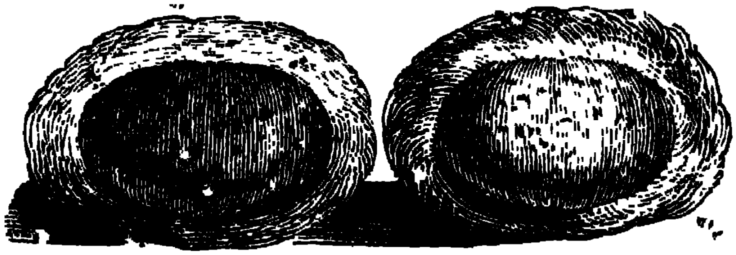
* Note V.

At the end of the third or fourth day the worm will have completed its task, and formed its cocoon. This has been compared in shape and size to a pigeon's egg. It is seldom, however, that the ball attains to so great a size. In the following representation the cocoons are drawn two thirds of the usual size, and are shown with part of the outward or floss silk removed.

Fig. 2.



When the insect has finished its labour of spinning, it smears the entire internal surface of the cocoon with a peculiar kind of gum, very similar in its nature to the matter which forms the silk itself; and this is no doubt designed as a shield against rain for the chrysalis in its natural state, when of course it would be subject to all varieties of weather. The silken filament of which the ball is made up is likewise accompanied, throughout its entire length, by a portion of gum, which serves to give firmness and consistency to its texture, and assists in rendering the dwelling of the chrysalis impervious to moisture. This office it performs so well, that when, for the purpose of reeling the silk with greater facility, the balls are thrown into basins of hot water, they swim on the top with all the buoyancy of bladders; nor, unless the ball be imperfectly formed, does the water penetrate within until the silk is nearly all unwound.

The continual emission of the silken material during the formation of its envelope, together with its natural evaporation, uncompensated by food, causes the worm gradually to contract in bulk; it becomes wrinkled, and the rings of its body approach nearer to each other and appear more decidedly marked. When the formation of the ball is finished, the insect rests awhile from its toil, and then throws off its caterpillar garb. If the cocoon be now opened, its inhabitant will appear in the form of a chrysalis or aurelia, in shape somewhat resembling a kidney bean, but pointed at one end, having a smooth brown skin. Its former covering, so dissimilar to the one now assumed, will be found lying beside it.

Fig. 3.

The account which has been given of the progressions of the silkworm shows that, in its various modifications, the animal organisation of the insect has been always tending towards its simplification. Count Dandolo, writing upon this subject, observes, "Thus the caterpillar is in the first instance composed of animal, silky, and excremental particles; this forms the state of the *growing caterpillar*: in the next stage it is composed of animal and silky particles; it is then the *mature caterpillar*: and lastly, it is reduced to the animal particles alone; and is termed in this state *the chrysalis*."

In the foregoing description, definite periods have been assigned to each age of the silkworm, in agreement with the fact as most generally experienced in the temperate climates of Europe. It has already been noticed that the progressions of the insects are accelerated by an increase of temperature; and some variation will equally be experienced where different modes of treatment are followed, and, in particular, where different periods of the year are chosen in which to produce and rear the worm Malpighius, in his "Anatomy of the Silkworm," says, that worms which he hatched in May were eleven days old ere they were attacked by their first sickness; others hatched in July were ten days, and those brought forth in August nine days, before they refused their food, preparatory to their first moulting. Eight days appear to be the most usual term for their first attack; and by his judicious treatment count Dandolo shortened even this term by two days. In Europe, except where recourse is had to artificial aid, the term of the insect's caterpillar state is usually that which has been already mentioned.

Dr. Anderson informs us, that in Madras the silkworm goes through its whole evolutions in the short space of twenty-two days. It appears, however, that the saving of time, and consequently of labour, is the only economy resulting from the acceleration; as the insects consume as much food during their shorter period of life, as is assigned to the longer-lived silkworms of Europe.

Sudden transitions from cold to heat, or from heat to cold, are highly injurious to the silkworm; but it can bear a very high degree of heat, if uniformly maintained, without sustaining injury. Count Dandolo observed, that "the greater the degree of heat in which it is reared, the more acute are its wants, the more rapid its pleasures, and the shorter its existence." Monsieur Boissier de Sauvagues made many experiments on this point. One year, when by the early appearance of the mulberry leaves, which were developed by the end of April, he was forced to hurry forward the operations of his filature, he raised the heat of the apartment in which the newly hatched worms were placed to 100°; gradually diminishing this during their first and second ages to 95°. In consequence of the animal excitement thus induced, there elapsed only nine days between the hatching and the second moulting inclusively. It was the general opinion of those cultivators who witnessed the experiment, that the insects would not be able to exist in so intensely heated an atmosphere. The walls of the apartment, and the wicker hurdles on which the worms were placed, could scarcely be touched without inconvenience, and yet all the changes and progressions went forward perfectly well, and a most abundant crop of silk was the result.

The same gentleman, on a subsequent occasion, exposed his brood to the temperature of 93° to 95° during their first age; of 89° to 91° in the second age; and remarked that the attendant circumstances were the same as in his former experiment, the changes of the worm being performed in the same space of time; whence he came to the conclusion, that it is not practicable to accelerate their progress beyond a certain point by any superadditions of heat. In both these experiments the quantity of food consumed was as great as is usually given during the longer period employed in the common manner of rearing. After the second moulting had taken place in the last experiment, the temperature was lowered to 82°; and it is remarkable that the worms occupied only five days in completing their third and fourth changes, although others which had been accustomed to this lower degree from their birth occupied seven or eight days for each of these moultings. It would therefore seem that the constitution of the insects can be affected, and an impetus given to their functions at the period of their first animation, which accompanies them through their after stages. So far from this forcing system proving injurious to the health of silkworms, M. de Sauvagues found that his broods were unusually healthy; and that while the labours of cultivation were abridged in their duration, much of the attendant anxiety was removed.

Like other caterpillars, the silkworm is not a warm-blooded animal, and its temperature is therefore always equal to that of the atmosphere in which it is placed. In the silk-producing countries, where modes of artificial heating have not been studied practically and scientifically, as they have of late in England, the difficulty and expense that must attend the prosecution of this heating system form abundant reasons why it cannot be generally adopted. The great susceptibility of the insect to atmospheric influences would also in a great degree render unsuitable the more common arrangements for the purpose. The plan of warming apartments by means of stoves, in its passage through which the air becomes highly heated before it mixes with and raises the general temperature of the air in the chamber, is liable to this inconvenience,—that the portion so introduced, having its vital property impaired by the burning heat through which it has passed, injures, proportionally, the respirable quality of the whole atmosphere; an effect which is easily perceptible by those who breathe it. A better plan of heating has lately been suggested, and is coming fast into practice, of warming buildings by means of a current of hot water, which is, by very simple means, kept constantly flowing in close channels through the apartment, where it continually gives off its heat by radiation; and the degree of this being far below the point which is injurious to the vital quality of air, the evil before alluded to is avoided. If the expense of fuel be not too great, as compared with that of the labour which would be saved by this means, the adoption in silk countries of such a mode of raising and regulating the temperature might, probably, prove advantageous.

The silkworm remains in the form of a chrysalis for periods which, according to the climate or the temperature wherein it may be placed, vary from fifteen to thirty days. In India, the time is only eleven days. In Spain and Italy, eighteen to twenty days. In France, three weeks; and in the climate of England, when unaccelerated by artificial means, thirty days will elapse from the time the insect began to spin until it emerges in its last and perfect form. It then throws off the shroud which had confined it in seeming lifelessness, and appears as a large moth of a greyish white colour, furnished with four wings, two eyes, and two black horns or antlers which have a feathery appearance.

If left until this period within the cocoon, the moth takes immediate measures for its extrication: ejecting from its mouth a liquor with which it moistens and lessens the adhesiveness of the gum with which it had lined the interior surface of its dwelling, the insect is enabled, by frequent motions of its head, to loosen, without breaking, the texture of the ball; then using its hooked feet, it pushes aside the filaments and makes a passage for itself into light and freedom. It is erroneously said that the moth recovers its liberty by gnawing the silken threads; it is found, on the contrary, that if carefully unwound, their continuity is by this means rarely broken.

Fig. 4.

One of the most remarkable circumstances connected with the natural history of silkworms is the degree in which their bulk and weight are increased, and the limited time wherein that increase is attained. Count Dandolo, who appears to have neglected nothing that could tend to the right understanding of the subject, and to the consequent improvement of the processes employed, had patience enough to count and weigh many hundred thousand eggs, and to follow out to the ultimate result his enquiries respecting their produce. He found that on an average sixty-eight sound silkworms' eggs weighed one grain. One ounce*, therefore, comprised 39,168 eggs. But one twelfth part of this weight evaporates previous to hatching, and the shells are equal to one fifth more. If, therefore, from one ounce, composed of 576 grains, 48 grains be deducted for evaporation, and 115 for the shells, 413 grains will remain equal to the weight of 39,168 young worms; and, at this rate, 54,526 of the insects, when newly hatched, are required to make up the ounce. After the first casting of the skin, 3840 worms are found to have this weight, so that the bulk and weight of the insects have in a few days been multiplied more than fourteen times. After the second change, 610 worms weigh an ounce, the weight of the worms being increased in the intermediate time six fold. In the week passed between the second and third ages, the number of insects required to make up the same weight decreases from 610 to 144, their weight being therefore more than quadrupled. During the fourth age, a similar rate of increase is maintained: thirty-five worms now weigh an ounce. The fifth age of the caterpillar comprises nearly a third part of its brief existence, and has been described, by an enthusiastic writer on the subject, as the happiest period of its life, during which it rapidly increases in size, and prepares and secretes the material which it is about to spin. When the silkworms are fully grown, and have arrived at their period of finally rejecting food, six of them make up the weight of an ounce. They have, therefore, since their last change, again added to their weight six fold.

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* This ounce contains 576 grains; 8·5325 of these grains equal seven grains troy. One ounce avoirdupoise is therefore equal to about 533 of these grains, and between $1\frac{1}{12}$ and $1\frac{1}{13}$ ounce avoirdupoise equals one of the above ounces.

It is thus seen that, in a few short weeks, the insect has multiplied its weight more than nine thousand fold! From this period, and during the whole of its two succeeding states of being, the worm imbibes no nourishment, and gradually diminishes in weight; being supported by its own substance, and appearing to find sufficient occupation in forming its silken web, and providing successors for our service, without indulging that grosser appetite which forms the beginning and the end of their desires during their caterpillar existence.

The moth enjoys its liberty for only a very brief space. Its first employment is to seek its mate; after which the female deposits her eggs; and both, in the course of two or three days after, end their being.

It is worthy of remark, that in putting on its wings the insect does not acquire a greater wish for change than characterises its former state of life. It remains, with the sole exception just named, fixed at one spot, its wings serving only by their fluttering to assist the moth in moving the few inches which may be necessary in fulfilling one of the ends of its existence.

The number of eggs produced by the female moth is variously stated; some accounts mention 250, while others reckon 400 to 500 as the usual number. This varies, no doubt, with the circumstances wherein the moth is placed. Count Dandolo obtained an ounce of eggs from 180 cocoons, in which the sexes were equally divided. Pullein states that 200 cocoons are necessary for the production of that quantity; and in the Cours d'Agriculture, 240 cocoons are said to yield only an ounce of eggs.

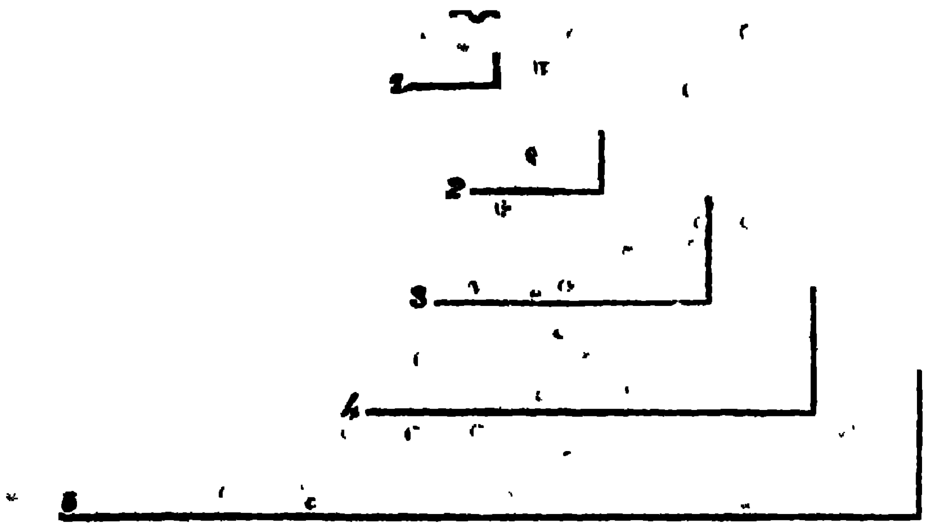
The relative length, at each age, of a worm which attains its greatest length, are, —

at hatching, unity or	1
at the end of the first age	4
of the second age . . .	6
of the third age	12
of the fourth age . . .	20
of the fifth age	40

The worm measures sometimes, when at its greatest length, more than three inches; but few attain to so great dimensions. The following lines show the proportions of the silkworm at each age of its life.

The small curved line at the top represents the worm when just hatched; the lines to which are attached the numerals 1, 2, 3, 4, show the sizes at the ages corresponding to those numbers, and the lines No. 5 describe its dimensions shortly before it prepares to spin. The horizontal lines represent the lengths, and the perpendicular lines the diameters of the insect.

Change of climate materially affects for a time the breed of silkworms. In attempting, therefore, to naturalise them in any place, it is important to procure eggs from some country of the same temperature. Where this is impracticable, they should be brought from a colder, rather than from a warmer climate. A very small variation of temperature will produce a very marked effect. Monsieur Chazal relates, that worms hatched in the Mauritius, from eggs procured in Bengal, neither attained to their natural size, nor afforded the usual quantity of silk, which, besides, was of indifferent quality. His second brood, proceeding from the eggs of these imported worms, were larger, and yielded a better produce both in quantity and quality; but the insects did not fully recover the desirable qualities of their progenitors until the fourth generation.



In addition to the silkworms most commonly reared, there are two varieties of this insect, which are partially cultivated, and which require some description.

One of these is a small worm, which casts its skin only thrice, and goes through its caterpillar life in four days less time than the worm already described. Its eggs are about one seventh part lighter than those of the common species, 42,620 eggs being required to make up the weight of one ounce. The worms themselves, when arrived at their full growth, are only three fifths of the ordinary size and weight; and the balls which they make are in the like proportion: four hundred of these weigh only one pound. In forming this weight of cocoons, these worms do not consume quite as much food as the larger species. The orifices through which they draw the silken material are more minute than those of common silkworms; and the filament, which on that account is finer, has a more beautiful appearance. Their cocoons are also more perfectly formed, and, in equal weights, will yield a greater proportion of reeled silk than ordinary cocoons, 4363 affording, on an average, one pound of pure silk: each cocoon, therefore, furnishes little more than $2\frac{1}{10}$ grains of silk, which measures, if one ball be estimated with another, a very small fraction under four hundred yards.

They are considered by some persons as being delicate, but it does not appear that they call for a greater degree of attention than should be bestowed on other worms. Their eggs may readily be obtained in Italy.

The second variety becomes much larger than the common sort: their eggs, however, are not proportionally heavy, weighing little more than one thirtieth part beyond those of other worms: it requires 37,440 of them to make an ounce. When at their utmost growth, two of these insects will weigh as much as five common silkworms; and the weight of the cocoon which they construct is in nearly the same proportion.

The advantages offered to the cultivator by this description of worm, is economy in the quantity of food. In ordinary seasons, $12\frac{1}{2}$ pounds of mulberry leaves will nourish as many worms as produce one pound of cocoons, which is a saving of one tenth the average weight required for the production of a similar quantity by common worms. On the other hand, this variety occupies five or six days longer in passing through their mutations, and before they begin to spin. One hundred of their cocoons weigh a pound, and one thousand and ninety one of them will yield one pound of reeled silk: each [illegible], therefore, furnishes nearly $8\frac{1}{2}$ grains of silk, and the length of its thread is very nearly 1300 yards. This breed of worms is to be found in Friuli.*

The constitution of worms of this larger species, does not offer inducements for their adoption into more temperate climates; but the advantages offered by the smaller variety make them worthy of observation and experiment on the part of silk cultivators.

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* Friuli silk is said to be more troublesome and wasteful in its manufacture than that of either France or Lombardy; an effect which may be owing to their breed of worms.

CHAP. III.

MODE OF REARING SILKWORMS IN CHINA.

SILKWORMS SOMETIMES REARED ON TREES. — PRODUCE INFERIOR TO THAT SPUN IN HOUSES. — MODE OF DELAYING THE HATCHING OF EGGS. — METHOD OF HATCHING. — SITUATION OF REARING-ROOMS. — NUMBER OF MEALS. — NECESSITY OF PREVENTING DAMP. — OF PRESERVING CLEANLINESS. — SPACE ALLOTTED TO WORMS. — PREPARATIONS FOR SPINNING. — COLLECTION OF COCOONS. — DESTRUCTION OF CHRYSALIDES. — BUILDINGS EMPLOYED FOR REARING SILKWORMS IN INDIA.

Before entering upon any description of the methods practised in Europe for rearing silkworms, it appears desirable to give a brief account of the means employed for that end in China. It will be seen, from this sketch, how superior, in many respects, were the arrangements of the Chinese cultivators; and that in departing from the course so long pursued by them, Europeans made choice of modes less rational and simple for attaining the desired result. The enquiries and experiments of later days have brought us back from the confused procedures, which so long imparted uncertainty, and so frequently led to disappointment, and have introduced, instead, judicious and methodical arrangements.

In those parts of the empire where the climate is favourable to the practice, and where alone, most probably, the silkworm is indigenous, it remains at liberty, feeding at pleasure on the leaves of its native mulberry tree, and going through all its mutations among the branches, uncontrolled by the hand and unassisted by the cares of man. So soon, however, as the silken balls have been constructed, they are appropriated by the universal usurper, who spares only the few required to reproduce their numbers, and thus to furnish him with successive harvests. *

This silk, the spontaneous offering of nature, is not, however, equal in fineness to that which is spun by

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* Note W.

worms under shelter, and whose progressions are influenced by careful tendance. Much attention is, therefore, bestowed by the Chinese in the artificial rearing of silkworms. One of their principal cares is to prevent the too early-hatching of the eggs, to which the nature of the climate so strongly disposes them. The mode of ensuring the requisite delay is, to cause the moth to deposit her eggs on large sheets of paper: these, immediately on their production, are suspended to a beam of the room, and the windows are opened to expose them to the air. In a few days the papers are taken down and rolled up loosely with the eggs withinside, in which form they are hung again during the remainder of the summer and through the autumn. Towards the end of the year they are immersed in cold water wherein a small portion of salt has been dissolved. In this state the eggs are left during two days; and on being taken from the salt and water are first hung to dry, and are then rolled up rather more tightly than before, each sheet of paper being thereafter enclosed in a separate earthen vessel. Some persons, who are exceedingly particular in their processes, use a ley made of mulberry tree ashes, and place the eggs likewise, during some minutes, on snow water, or otherwise on a mulberry tree exposed to snow or rain.

These processes appear efficacious for checking the hatching, until the expanding leaves of the mulberry tree give notice to the rearer of silkworms that he may take measures for bringing forth his brood. For this purpose the rolls of paper are taken from the earthen vessels, and are hung up towards the sun, the side to which the eggs adhere being turned from its rays, which are transmitted to them through the paper. In the evening the sheets are rolled closely up and placed in a warm situation. The same proceeding is repeated on the following day, when the eggs assume a greyish colour. On the evening of the third day, after a similar exposure, they are found to be of a much darker colour, nearly approaching to black; and the following morning, on the paper being unrolled, they are seen covered with worms. In the higher latitudes the Chinese have recourse to the heat of stoves, to promote the simultaneous hatching of eggs.

The apartments in which the worms are kept stand in dry situations, in a pure atmosphere, and apart from all noise, which is thought to be annoying to the worms, and especially when they are young. The rooms are made very close, but adequate means of ventilation are provided: the doors open to the south. Each chamber is provided with nine or ten rows of frames, placed one above the other. On these frames rush hurdles are ranged, upon which the worms are fed through all their five ages. A uniform degree of heat is constantly preserved, either by means of stoves placed in the corners of the apartments, or by chafing dishes which from time to time are carried up and down the room. Flame and smoke are always carefully avoided: cow-dung dried in the sun is preferred by the Chinese to all other kinds of fuel for this purpose.

The most unremitting attention is paid to the wants of the worms, which are fed during the night as well as the day. On the day of their being hatched they are furnished with forty meals, thirty are given in the second day, and fewer in and after the third day. The Chinese believe that the growth of silkworms is accelerated, and their success promoted, by the abundance of their food; and therefore, in cloudy and damp weather, when the insects are injuriously affected by the state of the atmosphere, their appetites are stimulated by a wisp of very dry straw being lighted and held over them, by means of which the cold and damp air is dissipated.

It is affirmed by these accurate observers, that the quicker the worm arrives at its maturity, the greater is the quantity of silk which it spins. They say, that if the worms become fully grown in twenty or twenty-five days, each drachm weight of eggs will produce twenty-five ounces of silk; that if their maturity be delayed to the twenty-eighth day, only twenty ounces are obtained;

and that if thirty or forty days elapse between the hatching and the commencement of the cocoons, then only ten ounces are the result.

The Chinese are exceedingly careful in preserving the nicest degree of cleanliness in their establishments for rearing silkworms; being fully aware of the great importance which attaches to that particular.

The worms, as they increase in growth, have gradually more space assigned to them; so that the full-grown caterpillars have four times the scope that is allotted to them when newly hatched, and sometimes even more.

When the insects are about to commence their spinning, mats are provided, in the centre of which a strip of rush, about an inch broad, is fixed, and extended in a spiral form, or in concentric circles, over the whole surface of the mat, leaving an area of about an inch broad between each circle. Here the worms fix themselves to spin; and it is found that these receptacles occasion less silk to be wasted by them in floss, than when more space is allotted wherein their first threads can be spun. At this time the whole room is carefully covered with mats, to exclude the outward air and the light, as it is believed that silkworms work more diligently in darkness.

In seven days from the commencement of the cocoons they are collected in heaps, those which are designed to continue the breed being first selected and set apart on hurdles, in a dry and airy situation. The next care is to destroy the vitality of the chrysalides in those balls which are to be reeled. The most approved method of performing this is to fill large earthen vessels with cocoons, in layers, throwing in one fortieth part of their weight of salt upon each layer, covering the whole with large dry leaves resembling those of the water lily, and then closely stopping the mouths of the vessels. In reeling their silk, the Chinese separate the thick and dark from the long and glittering white cocoons, as the produce of the former is inferior.

In India, the climate admits of silkworms being reared in buildings resembling sheds rather than houses. They are composed of lattice-work, and their roofs are covered with thatch. The breadth of such buildings is usually fifteen feet, and their height eight feet; their length is regulated by the extent of accommodation required. In the centre of the apartment a path is left, of convenient width for the attendants to pass and repass in supplying the wants of their charge; and on either side are twelve tiers or stages, one above another, of open frame-work, or shallow boxes made of bamboo, in which the worms are placed. When ready to spin, each worm is individually transferred to a small cell formed with platted strips of bamboo.

CHAP. IV.

MODE OF REARING SILKWORMS IN EUROPE.

GREAT DEGREE OF CAREFULNESS REQUIRED. — ABSURDITIES FORMERLY BELIEVED CONCERNING SILKWORMS. — CHOICE OF EGGS. — MODES OF HATCHING. — USE OF STOVE-ROOMS. — THEIR TEMPERATURE. — CONVEYING OF WORMS TO REARING-HOUSE. — NECESSITY FOR CLASSING WORMS ACCORDING TO THEIR AGES. — REVEREND MR. SWAYNE'S APPARATUS. — SPACE ALLOWED TO WORMS. — MODE OF FEEDING. — QUANTITY OF LEAVES CONSUMED. — ARBOURS FOR SPINNING. — NECESSITY OF ATTENTION TO MINUTE POINTS IN MANAGEMENT. — REGULATION OF TEMPERATURE. — SILKWORMS WILL NOT SPIN IN COLD ATMOSPHERE. — VENTILATION. — EFFECT OF NOISE. — ELECTRIC INFLUENCE. — CONDUCTORS.

The various operations of an establishment for the production of silk are, ordinarily, all begun and concluded in the course of a few weeks; yet they call for a considerable degree of attention on the part of its conductor, and can hardly be brought to a successful issue without the aid of experience. This is especially the case in Europe, where atmospheric changes are continually arising, which in various ways influence the tender silk-producing insect. One false step in management might be fatal, and one day's relaxation of the breeder's cares would suffice to bring all his previous labours to nothing.

The degree of skilfulness and care thus required for the successful rearing of silkworms upon any useful scale, cannot be adequately estimated by the experience of those persons in England, who, as a matter of curiosity or of amusement, have watched over a few hundred worms, and have wound off the silk which these have furnished, unassailed by accident or misfortune. It is very natural to suppose, that what is so easily practicable with a small number, offers little difficulty as an extensive employment. If, however, the English breeder considers the time, however short it may have appeared, and the labour, however unimportant in his estimation, bestowed on his inconsiderable brood, and thence calculates the greater labour which must attend upon the rearing of hundreds of thousands, or, perhaps, millions of insects, its insignificance will disappear. He may then naturally imagine, how great is the importance of abridging that labour, of economising expense, and of providing in every way against accidents, which, if occurring to interrupt his amusement, would be merely vexatious, but upon the avoiding of which, under other circumstances, depend the subsistence and well-being of thousands.

Many treatises have appeared from time to time containing copious information for the guidance of silk cultivators. Partaking in the generally increasing intelligence, recent writers on this branch of industry have treated it rationally and practically; but it is remarkable, to how late a period this object, which addressed itself to the interests of extensive communities, was gravely made the subject of the most absurd and unphilosophic notions.

Pomet, chief druggist to Louis le Grand, and who in the latter part of the seventeenth century wrote his "General History of Drugs," a work by which he acquired considerable reputation, seriously, and with all the signs of credence, quotes from Isnard, the following directions for improving the breed of silkworms:—

"At the time when the mulberry leaves are ready to gather, which should be five days after their budding, in the beginning of the spring, they take a cow which is almost at calving, and feed her wholly with mulberry leaves, without giving her any thing else to eat of herbs, hay, &c. or the like, till she has calved; and this they continue for eight days longer, after which, they let the cow and the calf both feed upon this some days together, without any other mixture as before. They kill the calf after it has been filled or satiated with the mulberry leaves and the cow's milk, then chop it to pieces to the very feet, and without throwing any thing away, put all together, the flesh, blood, bones, skin, and entrails, into a wooden trough, and set it at top of the house, in a granary or garret till it is corrupted; and from this will proceed little worms, which they lay together in a heap with mulberry leaves to raise them afterwards, just as they do those which are produced from the eggs; so that those who deal considerably in them, never fail, every ten or twelve years, to raise them this way." The authority of Isnard upon the culture of silk was long considered unquestionable.

It is difficult to account for the origin of such a childish fable; and one is at a loss whether most to admire the impudence of the falsehood, or the credulity which led to its reception. Thousands, who, of their own knowledge could contradict the absurdity, were living in the very country where it was put forth, and yet in the capital of that country, we see a man of literature, and reputed to possess a degree of scientific knowledge equal to most in his day, stamping the assertion with the sanction of his authority. Still later than this, Lemery, who by his writings and lectures did much to disencumber chemical science from the clouds of ignorance wherein it was enveloped in his day, republished Pomet's work with a commentary, and preserved the above passage, venturing only to qualify its insertion with the very gentle remark, "this thought, however, wants confirmation."

The proper choice of eggs is the first care of the cultivator. From this he may relieve himself in succeeding seasons, the operations of his own filature producing the requisite quantity. The Italian writers on the culture of silk give very copious directions for choosing eggs, and for detecting and avoiding the fraudulent arts sometimes practised by their vendors.

Good sound eggs are of a bluish-grey colour; those which are yellow should on no account be purchased. It is common with the peasants whose eggs are of the latter description to give them so much the appearance of sound eggs, by washing them in muddy, dark-coloured wine, that considerable judgment is required to detect the cheat.

Where silkworms' eggs are brought from a distant country, much attention is demanded to prevent their premature hatching. This has been successfully accomplished by placing them, when newly laid, and carefully dried, in glass phials closely sealed to exclude air and moisture: the whole being then immersed in earthen pots filled with cold water, which must be renewed as often as it becomes warm.

The hatching process, until within a very few years of the present time, was usually conducted in a very immethodical or uncertain manner. Many cultivators depended on the spontaneous appearance of the worms, called forth only by the natural warmth of the advancing season. Others had recourse to the heat of manure beds, but the method most frequently employed was to foster them into life by the heat of the human body. The mode of accomplishing this, was to place a small silk or cotton bag containing one or two ounces of eggs in the bosom next to the skin. The persons with whom these deposits were intrusted were forbidden to use any violent exercise, lest their charge might be crushed, or otherwise sustain injury through the consequent inequality of temperature. It would have been unsafe to continue the bags in this position during the night, and it was therefore most usual to place them beneath the pillow, which was previously heated to the temperature of the human body, using precautions also against injury, by placing some stiff substance over the eggs. When this companionship had lasted three days, and it was judged that the worms were shortly about to appear, the eggs were very gently transferred to shallow boxes made of thin wood, similar to those used for containing wafers: these were placed between warmed pillows as before described; and if the hatching were still further delayed, fresh heated pillows were supplied through the ensuing day, and continued until the insects had burst their shells. Some persons used warmed pillows from the commencement, and avoided the system of human incubation.

Count Dandolo recommended and adopted the use of stoves for heating the apartment in which his eggs were hatched, and by such means rendered the operation in a great degree certain, removing, at the same time, much of the trouble by which it had previously been accompanied. Previously to placing the eggs in this heated atmosphere, the count caused the cloths to which the eggs adhered to be agitated for five or six minutes in a vessel containing water, in order to lessen the adhesiveness of the matter which retained them on the cloths. Having then suffered the water to drain from them during two or three minutes, the cloths were stretched out on tables, and the eggs were gently scraped from them by an instrument whose edge was not sufficiently sharp to cut the eggs, nor yet so blunt as to crush them. The eggs, thus removed, were placed in water and washed, still further to free them from gum, and to promote their separation from each other. If any floated on the surface in this washing, they were removed and destroyed as spoilt. The water again being drained from them, the eggs were next washed in some sound light wine, and gentle friction was used to perfect their mutual separation. They were then strained and dried, by being placed on an absorbing substance in a dry airy place, whose temperature was between forty-six and fifty-nine degrees of Fahrenheit's scale, there to await the proper moment for placing them in the stove room. It has always been customary in Italy to employ wine as a solvent for the gum which causes the eggs to adhere together, and which is thought to make the task of disengaging itself from the shell more difficult to the insect.

It has been suggested, that one hatching room, upon a sufficient scale, might be employed for the general accommodation, in bringing forth all the silkworms of the surrounding district; and if proper confidence could be placed in the proprietor of such an establishment, there is no doubt of its great convenience to the cultivators.

When eggs are first placed in the stove room, its temperature should be sixty-four degrees; on the third day this should be raised to sixty-six degrees; and on each following day the heat should be increased one or two degrees, so that on the tenth day it shall have reached eighty-two degrees, which point must not be exceeded. The degree of warmth required for hatching the eggs of silkworms depends very much, however, upon the temperature to which they have been exposed during the preceding winter. It is, therefore, important that this point should be considered, so as to avoid premature hatching on the one hand, and too great a retarding on the other, which would follow if the eggs had been exposed to any severity of cold.

When the eggs assume a whitish colour, it is a sign that they are about to be hatched; and now, by the aid of a magnifying glass, the worms may be seen formed within the shells. Sheets of white paper, abundantly pierced with holes, or otherwise pieces of clear muslin, should now be placed over the eggs, covering them entirely; when, as the worms come forth, they will climb through to the upper surface of the paper or muslin.

To collect the worms for the purpose of conveying them to the rearing house, small twigs of mulberry, with very few leaves, are placed on the paper. On these leaves the newly hatched worms immediately fix, and fresh twigs being constantly supplied to meet the wants of the continually increasing number of worms, the whole may be readily collected. When their removal to any considerable distance is necessary, this is easily and safely performed by placing the sheets of paper and mulberry twigs in boxes or well lined baskets, using every precaution to exclude the external air from the now delicate brood. The worms should be removed only in fine weather, and during the warmest part of the day, and they should be supplied with leaves for their consumption while on the road.

The apartment wherein the newly hatched worms are placed must be dry and warm, with its windows opening on opposite sides, that perfect ventilation may be obtained when desirable. The room should be furnished with a stove, and thermometers must be provided, that the temperature may be precisely regulated. Wicker shelves are usually placed around at convenient distances, and are lined with paper: on these the worms are placed. The greatest precautions must be taken to prevent the intrusion of rats and mice, as well as many of the insect tribe, as these are more or less destructive to silkworms. Smoke, and bad smells, are likewise considered prejudicial, and must be avoided.

All writers on the treatment of these insects agree in recommending, that worms which are not hatched at the same time should on no account be placed together. The neglect of this precaution would occasion constant trouble to the attendants; the changes occurring at different periods, it would be impossible to attend to the quantity of their food with the degree of regularity that is desirable. This point is so much insisted upon by many cultivators, that to avoid the evil, all eggs which remain unhatched beyond the second day after the first appearance of the worms are destroyed. It is said, also, that if those of a later birth are reared, they generally prove weak in constitution, and produce less than their proper quantity of silk.

The reverend Mr. Swayne, who some years ago bestowed much attention upon the culture of silk in England, proposed the use of a simple apparatus for receiving and feeding the worms during their caterpillar state. His plan offers advantages, in the important point of cleanliness, greater than those possessed by the wicker shelves usually employed, and it is thought that a description of it may prove useful.

The apparatus consists of a wooden frame, four feet two inches high, furnished with eight open drawers or slides, which can be readily thrust in or drawn out from the frame. The upper slide *a* is of paper, and designed to receive the newly hatched worms. The two slides, *b b*, are formed of catgut, the threads of which are about one tenth of an inch apart: these are for the insects in their second and third ages. The five slides, *c c* are of wicker-work or netting, and are appropriated to the insects in their more forward stages. Beneath each of the drawers, with the exception of that marked *a*, other slides of paper are inserted to receive the litter of the worms, which, by this means, may be frequently removed without occasioning any disturbance to the insects. These must not be retained in the upper drawers *b b* after they have become so large that their litter will not fall through the catgut bottoms: at this time they must be transferred to the wicker or netting slides, which, the inventor imagined would, from their greater number, offer space enough for the accommodation of as many full grown caterpillars as the upper drawer would con-

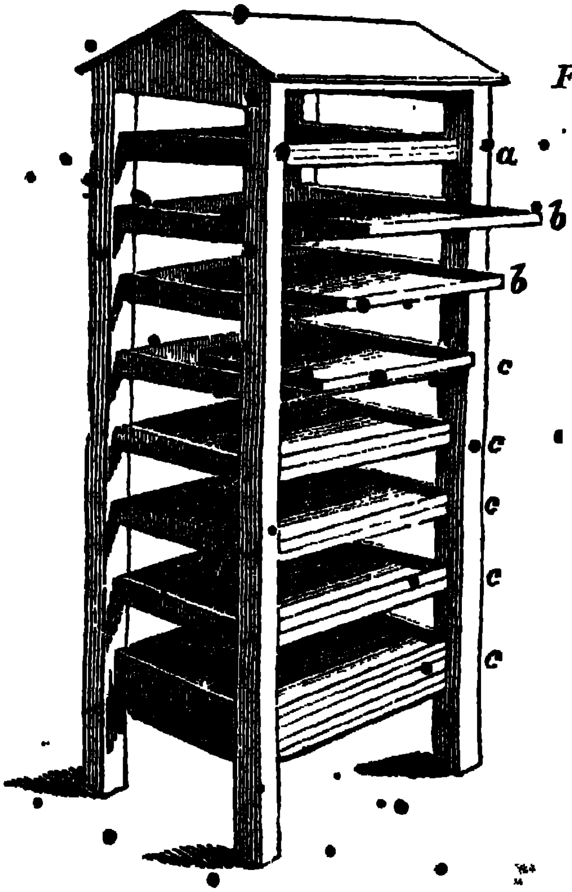


Fig. 5.

tain of those newly hatched. Under this arrangement the litter may be removed as often as the worms are fed.

It has been computed, that three square feet of surface afford ample space for the worms proceeding from an ounce of eggs, until the period of their first sickness is passed; and that this space should be multiplied thrice at each succeeding age. Count Dandolo considered that silkworms would be injuriously crowded in these dimensions, and recommended, that eight square feet should be allotted to the worms during their first age; fifteen feet for the second age; thirty-five feet for the third; eighty-two and a half feet for the fourth; and about two hundred feet for the fifth age. According to these proportions Mr. Swayne's apparatus is very imperfect, but this defect may easily be remedied in practice.

The mulberry leaves given to the newly hatched brood should be young and tender, and chopped into minute portions. These should be strewed evenly over the whole space of the shelves, that there may not be any unnecessary crowding of the insects in one spot. It is indeed advisable, when — as they sometimes will — the worms get heaped upon one another, that a leaf should be presented over them; to this some will quickly attach themselves, and may then be removed to a less crowded situation.

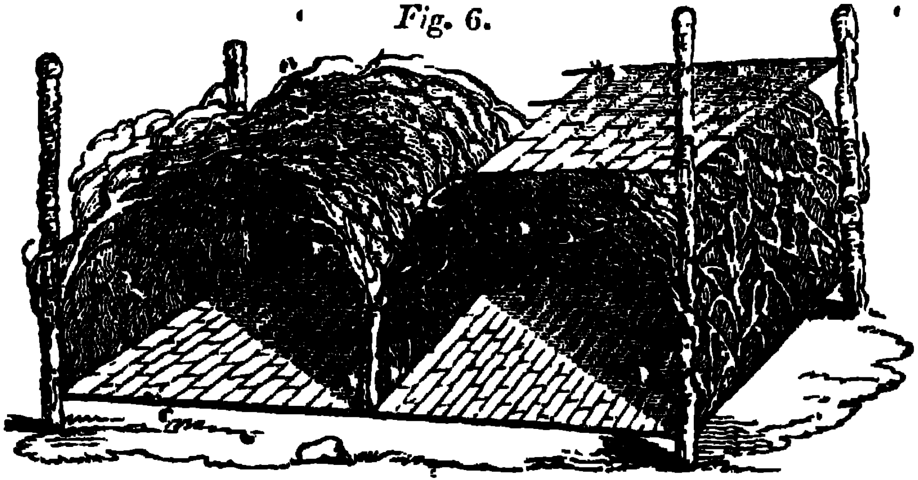
The worms proceeding from one ounce of eggs will consume six pounds of chopped leaves before their first moulting. Their second age is of shorter duration, but the greater size of the worms requires a more abundant supply of food; and eighteen pounds of leaves, chopped less finely than before, must be given, during its continuance, to the same number. In the third age, sixty pounds of leaves, still a little chopped, must be given; one hundred and eighty pounds will be consumed during their fourth age; and in their fifth and longest age, one thousand and ninety-eight pounds of leaves are devoured by these insects, which, when hatched a few weeks before, weighed less than an ounce.

These quantities are stated on the supposition that the worms are uniformly healthy. If many of them should die in the intermediate time, the weights mentioned will be in excess. On the other hand, if the season should be wet, the leaves will not contain the usual nourishment, with reference to their weight, and more must be given; whereas, if the season should prove more dry than ordinary, the nutriment in the leaves will be greater, and the quantity given may be diminished with advantage. The skill of the cultivator is shown by the weight of silk obtained in proportion to the leaves consumed; and his judgment is tasked to apportion these according to their nutritive properties. There will be no real economy in keeping the consumption of food too low: this, however, is not a common fault, and evils occur much more frequently from over-feeding and waste of leaves.

The worms should be fed with regularity four times a day; and intermediate repasts may be occasionally given, where their appetites appear to be increased in voraciousness. The advantage of chopping the leaves for young worms consists in the economy it introduces. Many thousand insects may, by this means, feed simultaneously upon a few ounces of leaves; whose fresh cut edges seem better adapted to their powers when newly hatched. If the leaves were given to them whole, a much greater number must be supplied than would be consumed while their freshness lasted, and great waste would be the consequence. The worms will always quit stale leaves for those which are newly gathered. Availing themselves of this fact, some persons provide wire-bottomed frames, which they cover, with fresh leaves, and lower them within reach of the worms. These instantly make their way through the reticulations of the wire, and fixing upon the leaves above, the frame may be raised and the litter removed without touching the worms, which might be injured by even the gentlest handling. This plan, as it occasions more trouble, does not appear so eligible as that of Mr. Swayne.

When the silkworms give indications that they are about to spin, little bushes must be provided for the purpose. These may be of broom, heath, clean bean stalks, or, in short, any bush or brushwood that is tender and flexible. These should be arranged upright in rows between the shelves, with intervals of fifteen inches between the rows. The bushes should be so high as to be bent by the shelf immediately above into the form of an arch. They should be so spread out, that a supply of air should freely reach every part, and ample space should be afforded for the worms to fix themselves and spin; otherwise, there is great hazard of their forming double cocoons, in which two worms assist in the preparation of one dwelling for both: the silk in these is so much less adapted to the purposes of the reeler, that a double cocoon is worth only one half the price of a single one. Inattention to this point is very common, and occasions constant losses. When the twigs already erected appear to be adequately furnished with worms, other similar hedges should be formed, parallel to the first. The spaces between the shelves will thus present the appearance of small avenues or arbours covered in at the top.*

Fig. 6.



The worms at this time require much careful watching, and occasional assistance must be afforded to those which are sluggish, that they may find an eligible spot for forming their cocoons. Those worms which appear still inclined to feed must be supplied with leaves: so long as the slightest inclination for food remains they will not attempt to form their cocoons. It will sometimes happen, that even after they have climbed among the branches for the purpose of spinning, they will again descend to satisfy their last desire for food. "I have seen them," says a minute observer, "stop when descending, and remain with the head downwards, the wish to eat having ceased before they reached the bottom." In such a case, they should be turned with their heads upwards, as the contrary position is injurious to them. If, at this time, many appear weak and inert, remaining motionless on the leaves, neither eating nor giving any sign of rising to spin, some means must be taken to stimulate them to the exertion. It was the ancient practice, and found to be efficacious for this purpose, to convey some pungent article, such as fried onions, into the apartment, the effluvia from which revived the worms, inciting some to take their last meal, and inducing others, whose desire for food had ceased, to climb the twigs and begin their labours. The same end is now generally and unfailingly attained, by removing the sluggish worms into another apartment, the temperature of which is higher.

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* Note X.

All these minute directions may perhaps appear frivolous; but it is only by an unceasing attention to these and the like minutiæ, that any tolerable success can be secured. When all the previous cares and labours of an establishment have been satisfactorily accomplished, if the hedges be not well formed, are irregular, or too thick in any parts, so as either to impede the circulation of air, or too far to limit the space in proportion to the number of worms, ill success will be sure to follow. Instead of the proper number of fine single cocoons, many will be double, others imperfect or soiled, and even some of the silkworms will be suffocated before the completion of their labours.

It is essential, in every age of the worms, to attend to the regulation of temperature in their apartments; and at no time is this more necessary than while they are forming their cocoons. If, at this time, they are exposed to much cold, they desist from their labours. Should the balls be sufficiently thin, the insects may be discerned, either quite inactive, or moving very slowly. On the temperature being raised, they will immediately resume their work with renewed activity, and will once more desist, if the cold be again allowed to exert its influence. After they have remained inactive from this cause for a short time, they put off their caterpillar form, and assume that of the chrysalis, without having sufficient energy to complete their silken covering.

The fifth volume of the transactions of the Society for the Encouragement of Arts, &c. contains a letter upon this subject from a gentleman, who relates, that in the summer of 1786 he had successfully reared to their full growth more than thirty thousand silkworms, when at the beginning of July, and just as they appeared about to spin, a chilling north east wind set in, and many of the worms became chrysalides, without attempting to spin. On the examination of these, it appeared that the glutinous matter in their silk reservoirs had become so congealed by the cold, as to resemble strong tendons, both in appearance and tenacity; which sufficiently accounted for the inability of the insects to draw forth the silk in filaments. Thousands of the worms changed in this profitless manner daily, until at length, the survivors being removed into an apartment artificially warmed, they immediately applied themselves to the performance of their usual functions. It is desirable that while silkworms are in the act of spinning, the temperature of their apartment should be maintained as high as 70 degrees, and it is at the same time equally important that free ventilation should be secured.

The opinion has been very generally entertained that violent noise disturbs, and injuriously affects the worms, and that any sudden report, as of fire-arms or thunder, will cause them to fall from their arbours. The peasants in Italy who attend on silkworms are so strongly of this opinion, that if the caterpillars omit to rise and spin after thunder has been heard, they consider its noise as the sole reason of the failure: they are always desirous of removing every cause for noise from about the establishment. This opinion appears, however, to be badly founded, and has been satisfactorily refuted by persons who have made experiments to ascertain the fact. Silkworms have been reared in all the bustle of a town, exposed to the barking of dogs, and to concerts of music, without in any way exhibiting signs of being affected by the noise. The following statement is conclusive. It is taken from the "Cours d'Agriculture," written by Monsieur Rozier, and recounts an experiment performed in the establishment of Monsieur Thomé, a considerable silk cultivator, and one of the earliest writers on the subject. These gentlemen, Messrs. Rozier and Thomé, in the presence of many witnesses, fired several pistol shots in the apartment where silkworms were either spinning, or rising preparatory to their labour; and the only worm that dropped was evidently a sickly insect, that could not have formed its cocoon under any circumstances.

It is seldom that any opinion upon a point of practice is entertained, without some ground for its existence. The Italian peasants, although certainly wrong in attributing any evil effects to the agency of noise, might have been correct had they ascribed the evil to that great accumulation of electricity in the atmosphere which attends the discharge of the fluid, from one cloud which is overcharged upon another which is deficient; or which accompanies the fluid in its passage between the clouds and the earth, until an equilibrium establishes itself in the mass. "Before this equilibrium is gained, however," says Monsieur Rozier, "we know that many persons exhibit symptoms of strong excitement, falling into convulsions, or even being affected by fever. Is it, then, surprising, that insects charged with a matter so highly electric as silk should become oppressed or overpowered by the superaddition of that which they receive from the atmosphere?" The peasants in the silk provinces of France have long been accustomed to place pieces of iron in the neighbourhood of the insects. If asked to assign their motive for this, their reply is, that their fathers and grandfathers did so before them, and that therefore the practice must be desirable. May we not imagine that this custom had its rise from the remarks of some philosophic observer of the laws of nature, and who, under other and more favourable circumstances, might have been led, by generalising, to anticipate the discoveries of Franklin?

Monsieur Rozier, in the work already quoted, recommended the use of metallic conductors; and himself proved their efficacy. In connection with some shelves containing silkworms, he placed thin iron wires, and carried them through the wall into a cistern of water. The remaining shelves were, in every other respect, similarly circumstanced to these; but he uniformly found that, when thus protected, the worms were decidedly more healthy and active than those unprovided with conductors.

CHAP. V.

GATHERING AND SORTING COCOONS.

METHOD OF GATHERING. — SORTING. — SELECTING FOR SEED. — PROPORTION SET APART FOR BREEDING. — METHODS OF DESTROYING VITALITY OF CHRYSALIDES — BY THE SOLAR RAYS. — IN OVENS. — BY STEAM HEAT. — PRESERVATION OF COCOONS. — SEPARATION OF DAMAGED. — GOOD COCOONS. — POINTED COCOONS. — COCALONS. — DOUPIONS. — SOUFFLONS. — PERFORATED COCOONS. — CHOQUETTES. — CALCINED COCOONS. — THEIR RELATIVE VALUE. — PROPORTION OF PURE SILK IN COCOONS. — PROPORTIONAL WEIGHT OF EGGS AND COCOONS; AND OF MULBERRY LEAVES. — QUANTITY OF REELED SILK FROM EACH COCOON. — WEIGHT AND SIZE. — LABOUR REQUIRED. — DEDUCTIONS.

In either three or four days from the commencement of its labours the silkworm completes its cocoon, and in seven or eight days thereafter the balls are gathered. Some persons do not wait longer than three or four days ere they reap their silken harvest.

It is usual to begin by gathering from the lower tier of arbours. In this proceeding no violence should be used to disengage the twigs, which must be gently handled, and consigned to those whose employment it is to separate the cocoons. These persons, as they pick off the balls, sort them; selecting those which are to be preserved for continuing the breed, and putting into distinct baskets all fine cocoons, those which are double, soiled, or anywise imperfect. The fine and well-formed balls are again subdivided into white and yellow, the latter colour embracing every shade from the deepest yellow to those which are merely tinged. A very few will sometimes be found having a pale green hue. The cocoons of a bright yellow yield a greater weight of reeled silk than the others, but as their deeper colour results from the greater proportion of gum wherein the colouring matter principally resides, any advantage from this source accrues only to the grower, the gummy substance being all boiled out previous to the weaving of the silk.

Raw silk which is of pale colour is found to take certain dyes better, and is on that account very generally preferred.

The selection of chrysalides for breeding is made from such cocoons as are perfectly sound, and whose threads appear to be fine; having their ends round and compact; and being a little depressed in the middle, as if tightened by a ring or ligature. The reason given for attention to these particulars, is the belief that worms producing such balls are of the strongest constitutions. Count Dandolo was of opinion that too much stress is laid upon this point, and that all cocoons which are perfectly formed are alike desirable for breeding. For this purpose an equal number of males and females must be preserved. The former are distinguishable by being sharper at the ends, and this, although not an unerring guide, proves sufficiently correct for all practical purposes. These cocoons are sometimes spread in thin layers on tables: but it seems a better practice, and one more generally adopted, is to string them together on a thread, care being taken not to pass the needle too deep into the silk. These strings, three or four feet in length, are then hung in festoons out of the reach of vermin. The floss is, in this case, usually removed, as it is found to oppose additional difficulty to the moth in its extrication.

In making the selection of cocoons for breeding, so as to insure the object of maintaining the numbers of his silkworms, the cultivator considers it necessary to set apart one sixtieth of his whole produce. This shows how considerable must be the loss sustained in this branch of the pursuit. If all the eggs produced by this proportion were found productive, the brood would by their means be trebled in the following season.

The next proceeding is that of destroying the vitality of the chrysalides in those cocoons which are to be reeled.

Various methods are employed for this purpose, according to the nature of the climate; the solar rays being in some instances found sufficient, no artificial means need be then resorted to. In this case, a calm and cloudless day is chosen, and the cocoons are left exposed to the scorching beams of the sun, during four or five hours in the middle of the day. They are next closely enwrapt in coarse cloths which have been exposed to the same heat, black cloths being chosen preferably on account of their absorbing a greater quantum of heat. These processes being repeated during several days, the destruction of the insect is usually attained. It is not safe, however, without examination, to confide in its efficacy; for this trial a few chrysalides must be stripped and pricked with a needle. If upon this they give no sign of animation, it may be safely concluded that their suffocation has been perfected.

In more temperate regions artificial means must necessarily be employed, and recourse is therefore had to the heat of steam, or of an oven; and most frequently the latter method is adopted, although there is no reason to doubt that the other, provided it could be efficaciously applied by means of convenient apparatus, would be more quick and certain in its operation, as well as productive of less injury to the texture of the silk. When the oven is used, the cocoons are placed in long shallow baskets, filled to within an inch of their tops, and covered, first with paper, and then with a cloth wrapper. The heat of the oven wherein the baskets are disposed has not been more precisely defined, than that it should be *very nearly* that of an oven from which loaves of bread have just been taken after being baked. The worms are exposed to this heat during an hour; and on their being withdrawn, it is ascertained by the examination of chrysalides, taken from the centre of each basket, whether the vitality of the worms is destroyed. Those chosen for examination having been, from their position, the least exposed to the heat, it is fairly presumed that if these be dead the whole are equally destroyed. On their removal from the oven, the baskets are wrapped in woollen cloths or blankets, and piled on each other. If the baking has been properly conducted, the blankets will soon appear profusely covered with moisture, and if this should not be seen, the baking has been either excessive or insufficient. If too great, the worms and cocoons will have been previously so much dried as to leave no further moisture to transude; if too little, the heat has not sufficiently penetrated to distil the liquor which the chrysalides contain, and the worms, in that case, will not be deprived of vitality.

It is obvious that very great nicety is required to limit the degree of heat to the exact point that will kill the chrysalides, and it is of great importance that this point shall not be exceeded, as the silken filaments would by such means be injured. For this reason steam would doubtless be much more frequently used, if any simple apparatus were introduced for the purpose. Where this agent is now employed, its efficiency is so limited that the operation is troublesome and the result uncertain.

A large wooden vessel is provided, into which boiling water is poured to the depth of two feet. This vessel has within it a wicker hurdle, entirely covering the water, and supported about one inch distant from its surface. The bottom of this hurdle is provided with a coarse porous cloth, easily penetrable by steam: on this the cocoons are placed, and are covered well over to confine the heat. When the water has become so cool that it no longer emits a body of steam, it must be changed for other boiling water; and it is considered necessary to continue this steaming process for two hours, before the destruction of the chrysalides can be considered certain. If steam were differently applied, a few minutes would suffice for perfecting this object. The cocoons, when removed from the steaming vessel, are covered over with the same care as is employed after baking, and they are left to cool very gradually. After this they are spread out in the air and sun to dissipate the moisture they have imbibed.*

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* Note Y

It is always desirable, where time can be allotted to the purpose, that the process of reeling should be performed without the delay which renders this destruction of the worms necessary. This, on large establishments, is evidently impracticable as regards any very considerable proportion of the produce; but it must be always performable to a certain extent; and it is proper to give the preference, in this respect, to such cocoons as appear the weakest: the others, which contain a greater proportion of gum, are thence better qualified to sustain heat without injury.

When the process, however conducted, for destroying the worms has been perfected, the cocoons are placed on shelves, and must be continually turned and looked over, lest they should become mouldy. If any appear spotted or otherwise damaged, they must be separated to prevent the injury spreading to those balls with which they are in contact, and should be immediately reeled to stay the progress of their own destruction. Large establishments for producing silk comprise in them buildings exclusively appropriated to this purpose, and which are called *coconières*. These are rooms fitted up with ranges of shelves from two to three feet above each other, and the whole are insulated from the walls and roof, lest the place should be invaded by rats or mice, which would infallibly destroy the cocoons in their eagerness to reach the chrysalides, of which they are immoderately fond. Still farther to guard against this havoc, the legs of the framing which supports the shelves should be enveloped in some furzy or prickly substance.

After the separation of cocoons for breeding, the gathering is divided into nine different qualities.

1. *Good cocoons* are those which have been brought to perfection: these are by no means the largest, but are compact and free from spots.

2. *Pointed cocoons* have one extremity rising in a point: these, after affording a little silk in reeling, break or tear at the point where the thread is weak, and they

cannot be wound further, as their fracture would occur as often as the thread reached the weak point.

3. *Cocalons* are rather larger than regular cocoons, but do not contain more silk, their texture being less compact. These are separated from the other kinds, because in winding they must be immersed in colder water, to avoid any furzing or entangling in the operation.

4. *Dupions or double cocoons.* The threads of these are so intertwined, that frequent breakings occur in reeling, and sometimes they cannot be wound at all. In any parcel of cocoons the proportion of these will usually amount to one per cent.

5. *Soufflons.* These are very imperfect cocoons, with a loose contexture, sometimes even to so great a degree as to be transparent: these cannot be wound.

6. *Perforated cocoons,* as their name denotes, have a hole in the end, and for that reason cannot be reeled, as the filament is found to be broken whenever it arrives at the perforation.

7. *Good choquettes* are cocoons wherein the insects have died before perfecting their task. These are known by the adhesion of the worm to the cocoon, which prevents its rattling when shaken. The silk of these is as fine as of the first-mentioned quality, but not so strong nor so brilliant, and they must be wound separately, as they sometimes furze in reeling.

8. *Bad choquettes* are defective cocoons, spotted or rotten. They furnish foul bad silk, and of a blackish colour.

9. *Calcined cocoons* are those wherein the worms, after having completed their cells, are attacked by a peculiar disease, which sometimes petrifies them, and at other times reduces them to a white powder. In the former case they are called comfit cocoons, from the resemblance which is borne by the withered worm to a sugar-plum. The quality of the silk, so far from being injured by this means, is generally excellent, and is even in greater quantity than in the cocoons of healthy worms. Comfit

cocoons may be distinguished by the peculiar rattling noise of the worm when shaken: they are so much esteemed in Piedmont, that they sell for one half more than good cocoons. They are not of frequent occurrence, and it is very rarely that so large a parcel as twenty-five pounds is met with.

The cocoons of the mountains are considered better than those produced on the plains: there is a greater proportion of white found among them; and although the balls are not so large, the worm is proportionally smaller than usual.

The relative value of cocoons, as stated in the paper already quoted from the American Philosophical Transactions, is as follows:—

Good cocoons - - -	100
Perforated - - - -	33
Soufflons - - - -	25
Royal cocoons, for seed - -	250
Royal cocoons, not chosen for seed	200

Cocoons lose in weight about 7½ per cent. in the course of ten days by the desiccation of the chrysalis: to those, therefore, who sell their cocoons previously to reeling, it is an advantage to dispose of them as soon as gathered. In 1000 ounces of perfect cocoons, the chrysalides weigh 845 ounces, the envelopes cast by the worms on becoming chrysalides 4½, and the pure cocoon 150½ ounces. Thus each healthy cocoon, as it is gathered, contains more than the seventh part of pure cocoon; but the quantity of reeled silk obtained seldom averages more than one twelfth in weight of the gathered cocoons. Mayet reckons, that if they are of superior quality, ten pounds of cocoons will produce one pound of silk; but that it more generally requires eleven or twelve pounds as gathered to yield that quantity. The same author likewise estimates 250 cocoons to weigh one pound: count Dandolo found that 240 of his made up that weight.

If no loss be sustained either in hatching the eggs or in rearing the worms, it is possible to obtain from each ounce of eggs 165 pounds' weight of cocoons: whatever less in weight is derived from this quantity of eggs indicates the exact amount of loss and damage sustained. In some parts of Italy, where the mode of management is very defective, only 45 pounds of cocoons are obtained from each ounce of eggs: the average quantity is about 100 pounds. Count Dandolo usually acquired on his establishment, from this weight of eggs, about 140 pounds of fine picked cocoons, in addition to the coarse floss with which they were surrounded.

In the year 1790, the Society for the Encouragement of Arts, &c. adjudged their gold medal to Mr. Salvator Bertezen, for his having produced five pounds' weight of silk from worms reared in England. This gentleman professed to have a superior breed of worms, and that his manner of managing them was also better than that usually followed. The above quantity of silk, which was wound in seven to nine fibres, was said to be the produce of 12,000 worms. This fact was much controverted at the time, and the quantity was deemed excessive with reference to the number of worms; but there now appears to be little reason for doubting its correctness, as the proportion very nearly agrees with the recorded experience of count Dandolo.*

This nobleman gives many elaborate calculations in his volume, the results of some of which may be found interesting. According to his experience, about 97½ pounds of mulberry leaves will suffice for the production of 7½ pounds of cocoons: these will yield about 18 ounces of pure cocoon, from which only 10 ounces of reeled silk are generally obtained. Thus the proportion between the weight of mulberry leaves consumed, and that of the pure cocoon produced, is about 87 to 1; and the proportional weight of mulberry leaf and of reeled silk is as 152 to 1. The ratio between the quantity of reeled silk drawn from the cocoon and the cocoon itself, may be greatly affected by the good or ill management to which the worm is subjected.

In the year 1814, when the season was extremely unfavourable to the rearing of silkworms, the count obtained 15 ounces of very fine silk from 7½ pounds of cocoons, and 13 ounces from the same weight of refuse cocoons. This fact speaks very highly for his excellent management. The proportion between the weight of silk which can be reeled, and the coarse floss which can only be spun, should, in perfect cocoons, be, in the average ratio of 19 to 1. In addition to this proportion of refuse floss, there is likewise to be gathered the outer floss, which is a loose, furzy texture, spun by the worms preparatory to the formation of their balls: the nature of this substance, together with the injury that it sustains in its disengagement from the arbours, entirely prevent its being reeled. It is usually in the proportion of about four to eleven with the silk of the cocoon.

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* Note Z.

The weight and length of reeled silk that can be obtained from each cocoon are very variously stated by different authors: in fact, the quantity is found to vary considerably, depending on many circumstances attendant on its formation. Some statements on the subject have been extravagantly absurd. Among others, Isnard, an old author, who has been before quoted, and whose delight in the marvellous has, on this point, found rivals even in the present day, affirms that the silk of one cocoon, when drawn out, will measure six miles in length, that is 10,560 yards! Count Dandolo, at once, contracts this measurement more within the limits of probability. He found that a silkworm's labours seldom exceed the production of 625 yards*; an astonishing quantity, when we reflect upon the brief period employed by so small a creature in its production. Surely it is unnecessary to call in the aid of exaggeration more highly to excite our wonder.

Miss Rhodes of Yorkshire found that one of her largest cocoons measured 404 yards. Pullein considers the average to be 300 yards. Miss Rhodes found that her cocoons weighed three grains each. Count Dandolo calculates the weight to be $3\frac{84}{100}$ grains, equal to about $3\frac{1}{4}$ English grains.

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* 1760 French feet.

The size of an ordinary cocoon of good quality is about an inch in its largest diameter, and one third less in its smallest diameter. The largest diameter of dupions is an inch and a quarter, and their smallest diameter three quarters of an inch.

The attendance required for the care of silkworms does not wholly occupy the time of those employed, and it is, therefore, difficult to ascertain its amount with correctness. Pullein states, that for rearing the worms produced from six ounces of eggs two attendants are necessary until the fourth age, and that after this period five or six persons are required. Count Dandolo, with his accustomed accuracy, reduces the time required for attendance upon the produce of five ounces of eggs to an equality with one hundred days' continuous labour of one individual.

From these data it is found, that to obtain one pound of reeled silk it requires 12 pounds of cocoons; that rather more than 2800 worms are employed in forming these cocoons; and that to feed these during their caterpillar state, 152 pounds of mulberry leaves must be gathered. This pound of reeled silk is capable of being converted into sixteen yards of gros de Naples of ordinary quality, or into fourteen yards of the best description.

Experience has shown that some regulation of temperature is necessary in producing the moths from the cocoons. If the heat in which these are placed be above 73°, their transition would be too rapid, and their productiveness would be lessened: on the other hand, if the temperature be below 66° the developement of the moths is tardy, and their produce equally falls below the due proportion.

The moths should begin to issue from their concealment in about fifteen days. The female deposits her eggs upon sheets of paper, or strips of linen, which are then hung in a cool situation, and when dry are preserved in an airy place, and securely shielded from damp and from vermin. In making choice of a situation wherein to store these eggs for the winter, although it is necessary to keep them cool, that premature hatching may be avoided, it is, on the other hand, indispensably requisite to preserve them from too intense a degree of cold: a temperature wherein water will freeze would be infallibly destructive of their vitality.

CHAP. VI.

DISEASES OF SILKWORMS.

GENERALLY RESULT FROM BAD TREATMENT. — SILKWORMS FREQUENTLY REARED IN COTTAGES OF PEASANTS. — COUNT DANDOLO. — HIS GREAT IMPROVEMENTS. — DANDOLIERES. — MEPHITIC AIR. — MOISTURE. — EXPERIMENTS. — JAUNDICE. — REMEDY. — CHLORINE GAS. — CHLORIDE OF LIME. — FUMIGATION. — LIGHT NOT INJURIOUS. — DESCRIPTION OF APARTMENTS ALLOTTED TO SILKWORMS IN COTTAGES. — ILL EFFECTS WHICH ARISE TO THEIR ATTENDANTS.

The silkworm is said to be subject to many diseases. There is reason for believing that most or all of these are either the consequences of bad treatment, or are easily counteracted by simple remedies. Count Dandolo, to whose recorded experience reference has so often been made in these pages, was obliged to have recourse to other cultivators for the means of describing diseases that did not exist in his own establishment.

The custom which prevails in Italy and France of distributing silkworms to be reared in the dwellings of the peasantry has confined the management principally to the hands of ignorance and prejudice; and little or no improvement had in consequence been made in this part of rural economy until count Dandolo devoted himself to its reformation, and thereby promoted a branch of industry highly important to the prosperity of his native country. This nobleman pursued the occupation with patriotic and philosophic aims far different from such as usually characterise pursuits of business. He brought scientific knowledge and enlightened views to the subject, and afforded a clear exemplification of the fact, that there is no process, however simple, no employments, however humble, and which might apparently be consigned without injury to the hands of the untaught and unreflecting, that do not call for the head as well as the hand of man, to conduct them on rational principles, and to derive from them all the beneficial results they may be made capable of yielding. It is seldom that objects of profit are thus undertaken and pursued. It most generally happens, that toils of this nature are assumed from necessity, by persons who think only of rendering them subservient to the calls of that necessity; who have neither mind nor leisure for experiments; and who, if, by departing from the beaten track, they have made a greater proficiency than their rivals, are too prone to keep secret their discoveries with a view to individual advantage. Count Dandolo was not thus satisfied to find out and to pursue the most advantageous methods, but widely disseminated the knowledge of his mode of treatment, not only by his writings, but by inviting the great proprietors, his countrymen, to send pupils to him, who might obtain practical instruction in his methods. These pupils sometimes occasioned great losses to him, as in order to their acquiring the necessary degree of skill, they were sometimes allowed to act upon their own suggestions. "But this signifies little," he would say, "compared to the advantage of diffusing and naturalising the improved art of rearing silkworms by means of these pupils." Shortly after the publication of his treatise, large establishments were formed in Lombardy, according to his recommendation: these were called *Dandolières*, as a testimony of respect for his disinterested philanthropy.

The causes which principally engender diseases in the silkworm appear to exist in either damp, stagnate, or mephitic air. Some experiments tried in order to ascertain the fact show that damp air is even more prejudicial to them than mephitic (carbonic acid) gas. If a silkworm be introduced into a receiver charged with carbonic acid gas, and in which a bird would instantly die, although the worm quickly exhibits signs of uneasiness and suffering, it will live for ten, fifteen, or perhaps twenty minutes: no warm-blooded animal could continue alive in such an atmosphere for half that time. If, after remaining a few minutes, the worm be withdrawn from the receiver, it will not exhibit any sign of injury, but will be, apparently, as healthy as before inhaling this pernicious gas. The silkworm appears indued with the power to seize upon the minutest portion of vital air which may be held by water, as it will live for some minutes immersed in this fluid, particularly in its first ages; and, even when seemingly dead, it will revive if taken out. It would seem, however, that when its power of breathing is obstructed, the worm instantly dies: if, instead of plunging it in carbonic acid gas, or in water, its eighteen breathing holes are sealed up with grease, it expires instantaneously.

If a healthy silkworm be confined in a vessel, the air in which is charged with moisture, and heated to the temperature of 88° or 90°, it will very soon exhibit symptoms of indisposition, and reject food; the skin will slacken, the muscles soften, and contraction cease. In a short time evaporation will be obstructed, the secretions indispensable to vitality, which are effected in this animal by means of contraction *, will be suspended, and ere long it will perish. A warm-blooded animal, on the contrary, if sufficiently supplied with pure air, can live without any suffering, and perform all its functions without inconvenience, in such a temperature, whatever be the attendant degree of moisture. This proves how different is the structure of these two classes of animals.

In the southern departments of France, it is very common to see silkworms attacked by a disease which, in consequence of the colour assumed by them, is called the jaundice. Very careful examination is continually made for the discovery and removal of worms which may be thus attacked, lest the disease, which is contagious, should spread to others. It is stated in the Bulletin Universel, that the abbé Eperic of Carpentras had recourse in this case to a remedy, or rather a pre-

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* The skin of the silkworm has so great a power of contraction, that on being cut through it shrinks in the manner of an elastic substance that has been drawn out.

ventive, which, though apparently dangerous, has been justified by the uniform success of twenty years. By means of a fine silk sieve he powdered his worms with quicklime, and after this gave them mulberry leaves moistened with a few drops of wine; these the insects instantly commenced devouring with an eagerness greater than that which they usually exhibited, and not one of the hurdles upon which the worms were thus treated ever appeared infected with jaundice. It was at first supposed that the cocoons might be injured by this process; but this is not the case, and the method is now very frequently adopted in the department of Vaucluse.

It is well known that decayed leaves emit mephitic air abundantly, and the lime may have been efficacious in absorbing and fixing this as it was generated, leaving the atmosphere inhaled by the insects in a desirable state of purity.*

Mons. Blanchard records the following experiment, which satisfactorily proves the efficacy of the use of lime:—"I procured," he said, "four glass jars, nine inches deep and five in diameter, and provided them with cork stoppers. In each of these glasses I placed twelve silkworms at their second age; these were fed four times a day, and I confined them in this kind of prison all their lives, without taking away either their dead companions or their litter. I sprinkled with lime the worms of only two of these jars, and kept the two others to compare with them. In those without lime, I never obtained more, or less than three, small and imperfect cocoons, and in the two that were sprinkled with lime I had very often twelve, and never less than nine fine full-sized firm cocoons." Mons. Blanchard ascertained, by many trials, that the worms were not incommoded when covered with a large portion of lime.

Count Dandolo advises fumigation with chlorine gas; but the mode of producing this from black oxide of manganese, common salt, and sulphuric acid, might be attended with unpleasant consequences, if intrusted to ignorant or careless hands, and to inhale the vapour as generated is not only unpleasant but dangerous. Chloride of lime, the use of which is attended with highly beneficial results as a disinfectant, and in neutralising the pernicious effects of mephitic vapours, might prove advantageous in silkworm establishments, producing all the good effects of fumigation with chlorine gas, without hazarding any of the pernicious results which might accompany the latter application.

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* Note A.

Among the peasants of France and Italy there is a practice of fumigating the room where the insects are kept with some kind of aromatic gum or odoriferous plant, but these only serve to conceal without correcting the effluvia which should warn the attendants of the necessity for cleanliness, and instead of removing increase the evil.

Many persons believe that light is injurious to silkworms; but, so far from this opinion being correct, the opposite belief would probably be nearer to the truth. In its native state, the insect is of course exposed to light, and suffers no inconvenience on that account; and it has been observed by one who gave much attention to the subject, that in his establishment, "on the side on which the sun shone directly on the hurdles, the silkworms were more numerous and stronger than in those places where the edge of the wicker hurdle formed a shade." The obscurity wherein the apartments are usually kept has a very pernicious influence on the air: the food of the worms emits in light oxygen, or vital air, while in darkness it exhales carbonic acid gas, unfit for respiration. This well-known fact occurs alike with all leaves similarly circumstanced.* To the bad effects thus arising from the exclusion of the sun's rays, another evil is added by the nature of the artificial lights employed being such as still further to vitiate the air.

An almost incredible quantity of fluid is constantly disengaged by evaporation from the bodies of the insects; and if means be not taken to disperse this as it is produced, another cause of unwholesomeness in the air arises.

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* Note B B.

Noticing this, count Dandolo observes, "This series of causes of the deterioration of the air which the worms must inhale may be termed a continued conspiracy against their health and life; and their resisting it, and living through it, shows them to have great strength of constitution."

Before this nobleman so zealously undertook the work of reform, the poor silkworms had to struggle through a miserable existence, until, their numbers thinned by death, and their frames weakened by disease, they feebly began to spin that thread which would have been produced superior in quality and much greater in quantity had they been more judiciously tended. By his methodical arrangements, the accidents of seasons and external temperature are no longer formidable. In 1814, a year peculiarly unfavourable for rearing these insects, and which proved extensively fatal in other establishments, he continued his operations with the same unvaried regularity, and, with perhaps increased precautions, was ultimately rewarded by the usual success.

In noticing the system already mentioned of distributing silkworms among the dwellings of the peasantry, count Dandolo gives the following distressing picture: — "In general the rooms appropriated to rearing silkworms among the tenants, farmers, and common cultivators, have the appearance of catacombs; I say in general, for there are some few who, although they may not have all the requisites for rearing worms in perfection, yet have care sufficient to preserve them from any very severe disease.

"I have found, on entering the rooms in which these insects were reared, that they were damp, ill lighted by lamps fed with rancid oil; the air corrupt and stagnant to a degree that impeded respiration; disagreeable effluvia disguised with aromatics; the wickers too close together, covered with fermenting litter upon which the silkworms were pining. The air was never renewed except by the breaches which time had worn in the doors and windows; and what made this more sad and deplorable was the knowledge that the persons who attended to these insects, however healthy they might have been when they entered upon the employment, lost their health, their voices became hollow, their hues pallid, and they had the appearance of valetudinarians, as if issuing from the very tombs, or recovering from some dreadful illness."

CHAP. VII.

ATTEMPTS TO SUBSTITUTE OTHER FOOD FOR MULBERRY LEAVES IN REARING SILKWORMS.

DOCTOR BELLARDI'S EXPERIMENT. — LETTUCE LEAVES. — COMPARATIVE PRODUCE OF WORMS FED WITH THESE AND WITH MULBERRY LEAVES. — MISS RHODES'S EXPERIMENTS. — LETTUCE LEAVES SUCCESSFULLY USED IN A HOT-HOUSE. — MRS. WILLIAMS'S EXPERIMENTS. — NATURAL ANTIPATHY OF SILKWORMS. — LEAVES OF SCORZONERA. — RECENT ATTEMPT TO REAR SILKWORMS IN ENGLAND. — ABANDONED FOR WANT OF SUFFICIENT AND APPROPRIATE FOOD.

It must always be a subject of anxious attention with the rearer of silkworms so to time the hatching of his eggs as to cause the coming forth of the living insects at the season when the mulberry tree first comes into leaf. By the aid of artificial means, and with methodical arrangements, this would appear to be a very simple affair; and yet so great have the difficulties been in practice, that various expedients have from time to time been proposed and attempted for combating them.

Great industry has been employed to seek out some substitute for the natural food of the worm, which should be readily procurable at all seasons, and in sufficient abundance to render the cultivator independent of the chances which attend the budding of the mulberry tree. Dr. Lodovico Bellardi, a learned and ingenious botanist of Turin, after making numerous experiments, and failing to discover any eligible substitute for the mulberry, at length proposed a method of feeding such silkworms as should be prematurely hatched, upon leaves of the preceding season carefully dried and prepared for the purpose. The trials made by the doctor were accompanied by all the success he could desire.

The leaves which had been gathered in fine weather towards the close of the preceding autumn, and before any injury from frost could have been experienced, were first spread on cloths and dried in the sun, and then reduced to powder; this was preserved through the winter in a perfectly dry place. Before giving it as food to his newly hatched brood, the powder was slightly moistened with water, and, a thin layer of it being placed around the insects, they immediately and with avidity began to feed, preferring it to every substitute which was offered, and thriving upon it satisfactorily.

While the hope still remained of naturalising the silkworm in England, the means of procuring a sufficient supply of appropriate food was considered as one of the greatest obstacles to its success; and the attention of such persons as interested themselves in the pursuit was consequently engaged, in ascertaining by experiment whether other leaves than those furnished by the mulberry tree might not be favourably substituted.

Among others, the Rev. Mr. Swayne exhibited much anxiety for the success of this object, with the praiseworthy desire of providing profitable employment for such of the poorer classes as might be too feeble for manual labour, most of the duties required in attendance upon the silkworm being such as can easily be fulfilled by women, children, and aged persons.

This gentleman made various trials as to the relative merits of different kinds of nourishment. For this purpose he placed equal numbers of newly hatched worms in three different boxes, which he numbered 1, 2, and 3. The contents of number 1. he fed entirely with leaves of the white mulberry; the insects in number 2. were nourished with those of the black mulberry; and the worms in number 3. were furnished with lettuce leaves until their first age was passed, and thereafter with the black mulberry leaf. These last worms were of a paler colour, and grew more rapidly than the others. The result, however, seems to prove that, although lettuce leaves may yield bodily nourishment to the insect, they contribute little towards the secretion of that peculiar matter which constitutes its value. When the spinning had been completed, twelve of the finest cocoons were chosen from each of the three divisions, and were found to be of the following weights: —

Cocoons of	No. 1.	weighed	7 dwts.	2 grains.
Ditto	- No. 2.	-	6	- 3
Ditto	- No. 3.	-	6	- 0

Neither of these results was very encouraging to the cultivator, but the experiment clearly evinced the superiority of the white mulberry over the other kinds of nourishment.

Many communications upon this subject are to be found in the volumes recording the Transactions of the Society for the Encouragement of Arts, &c. A letter from Miss Rhodes relates, that in the summer of 1785, she subsisted several thousand worms entirely on lettuce leaves during three weeks, and that for the remaining short term of their lives she afforded them their natural food. At the end of a month from their first hatching they began to spin, and eleven ounces of silk were procured from four thousand cocoons. After repeated trials, this lady had become convinced that silkworms could not safely be fed on lettuce leaves for a longer period than three weeks; as on persisting further in their use, the greater part of the worms died without forming their cocoons. Some, indeed, possessed sufficient vigour to spin and to produce perfect and well-formed balls, even when lettuce leaves had constituted their only food. Reasoning from this fact, Miss Rhodes was brought to suspect that the premature mortality of her brood was not altogether occasioned by the unwholesome nature of the aliment on which they had fed, but might be owing to some extraneous circumstance; and further observation led her to the conclusion that it was the coldness of the lettuce leaves rather than any inherent property which made them detrimental. This lady having thence suggested that if the worms were kept in a higher temperature, they might be successfully supported through their lives on lettuce leaves, general Mordaunt caused a considerable number to be hatched and reared in his hot-house. These were fed entirely on lettuce leaves; they throve and went through all their mutations as satisfactorily as if fed with their natural nourishment; scarcely any among them died, and the number and quality of the cocoons that were gathered proved the entire success of the experiment. If a solitary trial be sufficient to establish a fact, this must certainly be satisfactory to those who consider it desirable to naturalise silkworms in this country, where owing to the inequality of seasons, the appearance of mulberry leaves must always be uncertain in regard to time. Lettuce leaves have an advantage over other vegetables which have been offered as substitutes for the mulberry, that they may be gathered in wet weather without themselves being wetted, as a lettuce, once cabbaged, resists the entrance of all moisture within; and the heart being always perfectly dry, ensures nourishment to the worm, free from that moisture which is always found to affect it injuriously.

Mrs. Williams, an earlier correspondent of the society whose "Transactions" have been quoted, gives a very minute and copious account of the various trials which she made of vegetable substances as substitutes for mulberry leaves. Having hatched her brood in severely cold weather, when even lettuces were not easily procurable, she offered to her worms the tender parts of blackberry leaves, and relates that the worms ate them greedily. She next presented to them young leaves of the elm, and reports that equal success attended this trial: encouraged by these facts, she then succeeded in causing the insects to feed on the leaves and flowers of the sweet cowslip and primrose. But meanwhile the mulberry had put forth its leaves, and having procured some of these for her brood, it was thenceforth vain to offer them any other kinds of food: all were rejected; and another proof was afforded, that the mulberry tree, which no other insect will attack, is alone adapted to the natural desires of the silkworm. Mrs. Williams records one peculiarity which discovered itself throughout her investigation; by no means could the worms be brought to touch any flower of roseate hue. Pinks, roses, sweet-williams, polyanthuses, were each in turn offered by this persevering lady, and were all rejected without hesitation. It is proper to remark, that these experiments of Mrs. Williams are not confirmed by those of any other person, but, on the contrary, that Miss Rhodes was unsuccessful in every endeavour to repeat them, and succeeded only in reconciling her silkworms to the use of lettuce and spinach.

Attempts to discover a substitute for the mulberry are not entirely abandoned even at the present time. It is recorded in the Bulletin Universel, for 1829, that mademoiselle Coge of Epinal has used with success the leaves of the scorzonera (viper-grass) for the nourishment of silkworms. The silk produced by worms fed on this leaf is represented to be in no respect inferior to that from worms kept on the natural food.

Notwithstanding, however, this last announcement, and the partial success so frequently recorded as attending the substitution of the lettuce, all practical cultivators of silk continue to be convinced that it would be unprofitable to feed their worms on any save their natural nourishment; and the most intelligent writers on the subject approve the practice of destroying, as useless, any worms, which through ill management may be hatched before the mulberry tree has put forth leaves sufficient for their support.

Recent attempts which have been made to rear silkworms in England do not offer much encouragement to the pursuit, except as matter of amusement. Some pairs of silk stockings of good quality are to be seen in the gallery of "The National Repository," woven from silk of home production. The worms which spun this were reared by Mrs. Allen of Wandsworth, the result of whose careful observations on this subject has been obtained.

The difficulty of procuring a sufficient and continuous supply of proper food was the reason why this lady was obliged to relinquish a pursuit in which she had taken much pleasure for four successive years.

Mrs. Allen's testimony strongly corroborates the necessity of extreme cleanliness in preserving the health of the worms. The most scrupulous attention seems to have been paid by her to this particular, as well as to the dryness of the leaves, and the temperature of the apartment wherein the insects were reared and set to spin; and yet a very great mortality was always experienced among them, scarcely more than one in five of the worms that were hatched coming to maturity and forming their cocoons. Of these it required 1009 to furnish an ounce of reeled silk, the floss being equal to a quarter of an ounce more. The cocoons were gathered in eight days from their commencement, and in eight days more were wound off. No necessity hence arose for destroying the vitality of the insects to prevent their piercing the balls. The chrysalides being placed in bran, in due time became moths and produced eggs, each female furnishing between 300 and 400.

CHAP. VIII.

ATTEMPTS TO PRODUCE SILK FROM DIFFERENT ANIMATE CREATURES.

THE SPIDER. — DISCOVERY BY MONS. BON. — MANNER OF SPIDERS PRODUCING THEIR WEB. — POWER OF PRODUCING THIS OF VARIOUS DEGREES OF TENUITY. — GREAT NUMBER OF FIBRES COMPOSING ONE FILAMENT. — DIFFERENT KINDS OF THREADS. — SPIDER BAGS. — SILK MADE FROM THESE BY M. BON. — MANNER OF ITS PREPARATION. — GREAT COMPARATIVE ADVANTAGES ADDUCED BY M. BON. — HIS SPIDER ESTABLISHMENT. — INVESTIGATIONS BY REAUMUR. — HIS OBJECTIONS. — SMALL PRODUCE OF SILK FROM SPIDERS. — THE PINNA. — DESCRIPTION. — DELICACY OF ITS THREADS. — REAUMUR'S OBSERVATIONS. — SPINNING ORGAN OF THE PINNA. — MANNER OF FORMING ITS THREAD. — HOW DIFFERENT FROM THAT OF LAND INSECTS. — POWER OF CONTINUALLY PRODUCING NEW THREADS. — "THE PINNA AND ITS CANCER FRIEND." — NATURE OF THEIR ALLIANCE. — MANNER OF TAKING THE PINNA. — ITS THREADS KNOWN TO THE ANCIENTS. — PECULIAR QUALITIES OF THIS MATERIAL.

THE useful properties possessed by the produce of the silkworm, and the value which it has acquired among civilised communities, have, at various times, led ingenious men to seek among the works of nature for other substances, which, presenting appearances analogous to that beautiful filament, might be made equally conducive to human convenience and adornment.

Some species of spiders are known to possess the power of not merely forming a web, but also of spinning, for the protection of their eggs, a bag somewhat similar in form and substance to the cocoon of the silkworm. At the commencement of the last century a method was discovered in France by Monsieur Bon, of procuring silk from these spiders' bags, and its use was attempted in the manufacture of several articles. The following particulars are gathered from a dissertation published at the time by M. Bon, and also from papers on the subject inserted in the volumes of the Royal Academy for the years 1710 and 1711.

Spiders are usually classed according to their difference of colour, whether black, brown, yellow, &c., or sometimes by the number and arrangement of their eyes: of these organs some possess no fewer than ten, others eight, and others again six. M. Bon has, however, noticed only two kinds of silk spiders, and these he has distinguished from each other as having either long or short legs, the last variety producing the finest quality of raw silk. According to this ingenious observer, the silk formed by these insects is equally beautiful, strong, and glossy with that formed by the bombyx. The spider spins minute fibres from fine papillæ, or small nipples, placed in the hinder part of its body. These papillæ serve the office of so many wire-drawing irons, to form and mould a viscous liquor, which after being drawn through them dries on exposure to the air, and forms the silk.

The celebrated naturalist M. Reaumur, who likewise bestowed considerable attention on these insects, discovered that each of their papillæ consists of a number of smaller ones, so minute as not to be discernible, and only made evident by the effects produced. If the body of the spider be pressed between the fingers, the liquor from which the threads are formed flows into the papillæ, by applying the finger against which, distinct threads may then be drawn out through the several perforations of each papilla. These threads are too fine to be counted with any accuracy, but it is evident that very many are sent forth from each of the larger papillæ. This fact tends to explain the power possessed by the spider of producing threads having different degrees of tenuity. By applying more or fewer of these papillæ against the place whence it begins its web, the spider joins into one thread the almost imperceptible individual filaments which it draws from its body; the size of this thread being dependent on the number of nipples employed, and regulated by that instinct which teaches the creature to make choice of the degree of exility most appropriate to the work wherein it is about to engage. M. Bon was able to distinguish fifteen or twenty fibres in a single thread, while Reaumur relates that he has often counted as many as seventy or eighty fibres through a microscope, and perceived that there were yet infinitely more than he could reckon; so that he believed himself to be far within the limit of truth in computing that the tip of each of the five papillæ furnished 1000 separate fibres: thus supposing that one slender filament of a spider's web is made up of 5000 fibres! *

The threads produced by spiders are of two kinds. The first, which serves only to form the web which the insect spreads to entrap its prey, is very fragile; while the second, which is used to enclose the eggs of the female, is much stronger, thus affording to them shelter from cold, and protection from other insects which might otherwise destroy them. The threads are, in this operation, wound very loosely round the eggs, in a shape resembling that of the cocoon of the silkworm, after it has been prepared and loosened for the distaff. When first formed, the colour of these spiders' bags is grey, but, by exposure to the air, they soon acquire a blackish hue. Other spider bags might probably be found of other colours, and affording silk of better quality, but their scarcity would render any experiment with them difficult of accomplishment; for which reason M. Bon confined his attention to the bags of the common sort of the short-legged kind.

These always form their bags in some place sheltered from the wind and rain, such as the hollow trunks of trees, the corners of windows or vaults, or under the eaves of houses. A quantity of these bags was collected by M. Bon, from which a new kind of silk was made, said to be in no respect inferior to the silk of the bombyx. It took readily all kinds of dyes, and might have been wrought into any description of silken fabric. M. Bon had stockings and gloves made from it, some of which

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* Note C C.

he presented to the Royal Academy of Paris, and others he transmitted to the Royal Society of London.

This silk was prepared in the following manner:—Twelve or thirteen ounces of the bags were beaten with the hand, or by a stick, until they were entirely freed from dust. They were next washed in warm water, which was continually changed, until it no longer became clouded or discoloured by the bags under process. After this they were steeped in a large quantity of water wherein soap, saltpetre, and gum-arabic had been dissolved. The whole was then set to boil over a gentle fire during three hours, after which the bags were rinsed in clear warm water to discharge the soap. They were finally set out to dry, during some days previous to the operation of carding, which was then performed with cards differing from those usually employed with silk in being much finer. By these means silk of a peculiar ash colour was obtained, which was spun without difficulty. M. Bon affirmed that the thread was both stronger and finer than common silk, and that therefore fabrics similar to those made with the latter material might be manufactured from this, there being no reason for doubting that it would stand any trials of the loom, after having undergone those of the stocking frame.

The only obstacle, therefore, which appeared to prevent the establishing of any considerable manufacture from these spider bags was the difficulty of obtaining them in sufficient abundance. M. Bon fancied that this objection could soon be overcome, and that the art of domesticating and rearing spiders, as practised with silkworms, was to be attained. Carried away by the enthusiasm of one who, having made a discovery, pursues it with ardour undismayed by difficulties, he met every objection by comparisons, which perhaps were not wholly and strictly founded on fact. Contrasted with the spider, and to favour his arguments, the silkworm in his hands made a very despicable figure. He affirmed that the female spider produces 600 or 700 eggs; while of the 100, to which number he limited the silkworm, not more than one half were reared to produce balls. That the spiders hatched spontaneously, without any care, in the months of August and September; that the old spiders dying soon after they have laid their eggs, the young ones live for ten or twelve months without food and continue in their bags without growing, until the hot weather, by putting their viscid juices in motion, induces them to come forth, spin, and run about in search of food.

Mons. Bon flattered himself by this partial comparison, that if a method could be found of breeding young spiders in apartments, they would furnish a much greater quantity of bags than silkworms. Of about 700 or 800 young spiders which he kept, hardly one died in a year; whereas, according to this gentleman's estimate, of 100 silkworms not forty lived to form their cocoons. His spider establishment was managed in the following manner:—having ordered all the short-legged spiders which could be collected by persons employed for the purpose, to be brought to him, he enclosed them in paper coffins and pots; these were covered with papers, which, as well as the coffins, were pricked over their surface with pin holes to admit air to the prisoners. The insects were duly fed with flies, and after some time it was found on inspection that the greater part of them had formed their bags. This advocate for the rearing of spiders contended that spiders' bags afforded much more silk in proportion to their weight than those of the silkworm; in proof of which he observed, that thirteen ounces yield nearly four ounces of pure silk, two ounces of which were sufficient to make a pair of stockings; whereas stockings made of common silk were said by him to weigh seven or eight ounces.

Some persons had imagined that the spider was venomous, and that this evil quality extended to the silk which it produced. Mons. Bon combated this prejudice by the assertion, that he had several times been bitten by spiders, when no injury had ensued; and that the silk, so far from being pernicious, had been found efficacious in stanching and healing wounds, its natural gluten acting as a kind of balsam. Determined upon extracting every possible good from this his favourite pursuit, he subjected the spider silk to chemical analysis, and obtained from it a volatile salt, preparing which in the same manner used for the *guttæ Anglicanæ*, once so famous all over Europe, he produced drops which, as he believed, possessed greater efficacy than even these: he called this preparation Montpelier drops, and recommended its application in all lethargic diseases.

The Royal Academy of Paris having considered the subject deserving of investigation, appointed M. Reaumur to enquire into the merits of this new silken material. In the course of his examination this naturalist discovered many serious objections, the narration of which will show the inexpediency of M. Bon's projected establishments. Mons. Reaumur urged that the natural fierceness of spiders rendered them wholly unfit to be bred and reared together. On distributing 4000 or 5000 into cells, in companies of from 50 to 100 or 200, it was found that the larger spiders quickly killed and ate the smaller, so that in a short time the cells were depopulated, scarcely more than one or two being found in each cell. To this propensity for mutual destruction, M. Reaumur ascribes the scarcity of spiders in comparison with the vast number of eggs which they produce. But if even it were possible to change their warlike nature and bring these insects together in peaceful community, there are other objections to deter from the attempt.

M. Reaumur affirmed, that the silk of the spider is inferior to that of the silkworm, both in lustre and strength, and that it produced proportionally less material available to purposes of manufacture. All this was satisfactorily proved; although in his reasoning some little exaggeration was likewise employed in opposition to the colouring of M. Bon. The thread of the spider's web was found capable of sustaining a weight of only two grains without breaking; and the filament of the bag, although much stronger than this, could only sustain thirty-six grains, while that of the silkworm will support a weight of two drachms and a half. "Thus five" (four?) "threads of the spider," said M. Reaumur, "must be brought together to equal one thread of the silkworm." Now it is impossible that these should be applied so justly over one another as not to leave little vacant spaces between them, whence the light will not be reflected; and, consequently, a thread thus compounded cannot equal in lustre a solid thread. It is another great disadvantage of the spiders' silk, that it cannot be wound off the ball like that of the silkworm, but must necessarily be carded; and therefore its evenness, which contributes so materially to its lustre, is destroyed. That this effect was in reality produced, is further confirmed by the testimony of M. le Hire, who, when the stockings of M. Bon were presented to the Royal Academy, immediately noticed their want of lustre.

Another objection urged by M. Reaumur against the rearing of spiders was the small quantity as well as deficient quality of the silk they produce. In making a comparison in this respect between them and the silkworm, extreme cases were taken, that the conclusion might be rendered more striking. "The largest cocoons," said this naturalist, "weigh four and the smaller three grains each; spiders' bags do not weigh above one grain each, and, after being cleared of their dust, have lost two thirds of this weight." He calculated, therefore, that the work of twelve spiders only equals that of one silkworm; and that a pound of silk would require for its production 27,648 insects. But as the bags are wholly the work of the females, who spin them as a deposit for their eggs, it follows that 55,296 spiders must be reared to yield one pound of silk: yet even this will be obtained from only the best spiders, those large ones ordinarily seen in gardens, &c., yielding not more than a twelfth part the silk of the others. The work of 280 of these would, therefore, not yield more silk than the produce of one industrious silkworm, and 663,552 of them would furnish only one pound of silk! This latter calculation is however decidedly erroneous in its several steps, and appears rather to be a flight of the imagination than the result of sober induction. The advantages of the culture of silk from the silkworm, when compared with its production from spiders, are so prodigious, and at the same time so evident, that to prove the futility of M. Bon's scheme needed not the aid of exaggeration.

Human ingenuity has been somewhat more successfully exercised in seeking, many feet below the surface of the ocean, for slender filaments the produce of an animal in almost a vegetative state of existence.

The *pinna* belongs, like the common edible muscle, to the order of the *vermes testacea*. The animal is a limax, its shell is bivalve, fragile, and furnished with a beard; the valves hinge without a tooth. The pinna does not fasten itself to rocks in the same situation as the muscle, but sticks its sharp end into the mud or sand, while the rest of the shell remains at liberty to open in the water. In common with the muscle, it has the power of spinning a viscid matter from its body, in the manner of the spider and caterpillar. Although the pinna is vastly larger than the muscle, its shell being often found two feet long, the threads which it produces are much more delicate and slender than those of the muscle, and scarcely inferior in fineness and beauty to the single filament of the comparatively minute silkworm. Threads so delicately thin, as may readily be imagined, do not singly possess much strength; but the little power of each is made up by the aggregate of the almost infinite number which each fish puts forth to secure itself in a fixed situation, and to preserve it against the rolling of the waves. The threads are, however, similar in their nature to those of the muscle, differing only in their superior fineness and greater length. These fish have, therefore, been distinguished by some naturalists, the one as the silkworm, the other as the caterpillar of the sea.

It was always well known that muscles have the power of affixing themselves either to rocks or to the shells of one another, in a very firm manner; yet their method of effecting this was not understood until explained through the accurate observations of M. Reaumur. He was the first naturalist who ascertained that if, by any accident, the animals were torn from their hold, they possessed the power of substituting other threads for those which had been broken or injured. He found that if muscles, detached from each other, were placed in any kind of vessel and then plunged into the sea, they contrived in a very short time to fasten themselves both to the sides of the vessel and to one another's shells: in this process, the extremity of each thread seemed to perform the office of a hand in seizing upon the body to which it would attach itself.

The threads issue from the shell at that part where it naturally opens, and, in affixing themselves to any substance, form numerous minute cables, by aid of which the fish steadies itself in the water. Each animal is furnished with an organ, which it is difficult to designate by any name, since it performs the office of so many members, and is the only indicator of the existence of vital powers in the creature. It is by turns a tongue, an arm, and sometimes a leg. Its shape resembles that of a tongue, and it is, therefore, most frequently called by that name. Whenever the fish requires to change its place, this member serves to drag its body forward, together with its cumbrous habitation: in performing its journey the extremity of this organ, which may then be called a leg, is fixed to some solid body, and being then contracted in its length, the whole fish is necessarily drawn towards the spot where it has fixed itself; and by a repetition of these movements, the animal arrives at its destination. It is not often that the organ is put to this use, as the pinna is but little addicted to locomotion: some naturalists indeed affirm that it is always stationary. The use to which the tongue is most frequently applied is that of spinning the threads. Although this body is flat, and similar in form to a tongue through the greater part of its length, it becomes cylindrical about the base or root, where it is much smaller than in any other part: at this lower end are several ligatures of a muscular nature, which hold the tongue firmly fixed against the middle of the shell; four of these cords are very apparent, and serve to move the tongue in any direction according to the wants of the fish. Through the entire length of this member there runs a slit, which pierces very deeply into its substance, so as almost to divide it into two longitudinal sections; this slit performs the office of a canal for the liquor of which the threads are formed, and serves to mould them into their proper form: this canal appears externally like a small crack, being almost covered by the flesh from either side, but internally it is much wider, and is surrounded by circular fibres. The channel thus formed extends regularly from the tip to the base of the tongue, where it partakes of the form of the member and becomes cylindric, forming there a close tube or pipe in which the canal terminates. The viscid substance is moulded in this tube into the form of a cord, similar to the threads produced from it, but much thicker, and from this cord all the minute fibres issue and disperse. The internal surface of the tube in which the large cord is formed is furnished with glands for the secretion of the peculiar liquor employed in its production, and which liquor is always in great abundance in this animal as well as in muscles.

Reaumur observed, that although the workmanship, when completed, of the land and sea animals, is the same, the manner of its production is very different. Spiders, caterpillars, and the like, form threads of any required length, by making the viscous liquor of which the filament is formed pass through fine perforations in the organ appointed for this spinning. But the way in which muscles form their thread is very different; as the former resembles the work of the wire-drawer, so does the latter that of the founder who casts metals in a mould.

The canal of the organ destined for the muscle's spinning is the mould in which its thread is cast, and gives to it its determinate length.*

Reaumur learned the manner of the muscle performing the operation of spinning by actually placing some of these fish under his constant inspection. He kept them in his apartment in a vessel filled with sea water, and distinctly saw them open their shells and put forth the tongue. They extended and contracted this organ several times, obtruding it in every direction, as if seeking the fittest place whereon to fix their threads. After these trials had been often repeated, the tongue of one was observed to remain for some time on the spot chosen, and being then drawn back with great quickness, a thread was very easily discerned, fastened to the place: this operation was repeated, until all the threads were in sufficient number, one fibre being produced at each movement of the tongue.

The old threads were found to differ materially from those newly spun, the latter being whiter, more glossy, and more transparent than the former, and it was thence discovered that it was not the office of the tongue to transfer the old threads one by one, to the new spots where they were fixed, which course M. Reaumur had thought was pursued. The old threads [illegible] severed from the spot to which they had been originally fixed were seen to be useless, and that every fibre employed by the fish to secure itself in a new position was produced at the time it was required; and, in short, that nature had endowed some fish, as well as many land insects, with the power of spinning threads, as their natural wants and instincts demanded. This fact was established incontrovertibly by cutting away, as close to the body as they could be safely separated, the old threads, which were always replaced by others in as short a space of time as was employed by other muscles not so deprived in fixing themselves.

"The pinna and its cancer friend" have on more than one occasion been made subjects for poetry. There is doubtless some foundation for the fact of the mutual alliance between these aquatic friends which has been thus celebrated; yet some slight colouring may have been borrowed from the regions of fancy to adorn the verse, and even the prose history of their attachment may be exposed to the same objection.

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* Mem. Acad. Par. 1711.

These fish are found on the coasts of Provence and Italy, and in the Indian ocean. The largest and most remarkable species inhabits the Mediterranean sea.

The scuttle-fish*, a native of the same seas as the pinna, is its deadly foe, and would quickly destroy it, if it were not for its faithful ally. In common with all the same species, the pinna is without the organs of sight, and could not, therefore, unassisted, be aware of the vicinity of its dangerous enemy. A small animal of the crab kind, itself destitute of a covering, but extremely quick-sighted, takes refuge in the shell of the pinna, whose strong calcareous valves afford a shelter to her guest, while he makes a return for this protection by going forth in search of prey. At these times the pinna opens her valves to afford him egress and ingress: if the watchful scuttle-fish now approach, the crab returns immediately with notice of the danger to her hostess, who, timely warned, shuts her door and keeps out the enemy. When the crab has, unmolested, succeeded in loading itself with provisions, it gives notice by a gentle noise at the opening of the shell, and when admitted, the two friends feast together on the fruit of its industry. It would appear an arduous, nay, almost an impossible task, for the defenceless and diminutive crab, not merely to elude its enemies and return home, but likewise to obtain a supply of provender sufficient to satisfy the wants of its larger companion. The following different account of the nature of this alliance is much more in agreement with probability:—

Whenever the pinna ventures to open its shell, it is immediately exposed to the attacks of various of the smaller kinds of fish, which, finding no resistance to their first assaults, acquire boldness and venture in. The vigilant guard, by a gentle bite, gives notice of this to his companion, who, upon this hint, closes her shell, and having thus shut them in makes a prey of those who had come to prey upon her: when thus supplied with food, she never fails to share her booty with so useful an ally.

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* This species is the Octopodia, with eight arms connected at their bottoms by a membrane: it is the Polypus of Pliny.

We are told that the sagacious observer Dr. Hasselquist, in his voyage about the middle of the last century to Palestine, which he undertook for objects connected with the study of natural history, beheld this curious phenomenon, which, though well known to the ancients, had escaped the attention of the moderns.

It is related by Aristotle* that the pinna keeps a guard to watch for her, which grows to her mouth, and serves as her caterer: this he calls pinnophylax, and describes as a little fish with claws like a crab. Pliny observes †, that the smallest species of crab is called the pinnotores, and being from its diminutive size liable to injury, has the prudence to conceal itself in the shells of oysters. In another place he describes the pinna as of the genus of shell-fish, with the further particulars that it is found in muddy waters, always erect, and never without a companion, called by some pinnotores, by others pinnophylax; this being sometimes a small squill, sometimes a crab, which remains with the pinna for the sake of food.

The description of the pinna by the Greek poet Oppianus, who flourished in the second century, has been thus given in English verse: —

> "The pinna and the crab together dwell,
> For mutual succour in one common shell;
> They both to gain a livelihood combine,
> That takes the prey, when this has given the sign;
> From hence this crab, above his fellows famed,
> By ancient Greeks was Pinnotores named."

It is said that the pinna fastens itself so strongly to the rocks, that the men who are employed in fishing it are obliged to use considerable force to break the tuft of threads by which it is secured fifteen, twenty, and sometimes thirty feet below the surface of the sea.

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* Hist. lib. v. c. 15.

† Lib. ix. 51. 66.

The fishermen at Toulon use an instrument called a cramp for this curious pursuit. This is a kind of iron fork, whose prongs are each about eight feet in length and six inches apart, and placed at right angles to the handle, the length of which is regulated by the depth of water. The pinnæ are seized, separated from the rock, and raised to the surface by means of this instrument.

The threads of the pinna have from very ancient times been employed in the manufacture of certain fabrics. This material was well known to the ancients, as some suppose, under the name of byssus *, and was wrought in very early times into gloves and other articles of dress and ornament. It appears that robes were sometimes made of this produce, since we learn from Procopius that a robe composed of byssus of the pinna was presented to the satraps of Armenia by the Roman emperor. †

A writer of the year 1782 evidently refers to the pinnæ marinæ, when he says, "The ancients had a manufacture of silk, and which, about forty years ago, was revived at Tarento and Regio in the kingdom of Naples. It consists of a strong brown silk, belonging to some sort of shell, of which they make caps, gloves, stockings, waistcoats, &c., warmer than the woollen stuffs, and brighter than common silk. I have seen such kind of silk in shells myself; I think it was of the pecten kind, but cannot be sure." ‡

Several beautiful manufactures are wrought with these threads at Palermo. They are in many places the chief object of the fishery, and the silk is found to be excellent. The produce of a considerable number of pinnæ is required to make only one pair of stockings. The delicacy of this singular thread is such that a pair of stockings made of it can be easily contained in a snuff-

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* Note D D. † Procopius de Edif. lib. iii. c. 1.

‡ The Young Gentleman and Lady's Philosophy. By Benjamin Martin, vol. iii. p. 179.

box of ordinary size.. Some stockings of this material were presented, in the year 1754, to pope Benedict XIV.; and, notwithstanding their extreme fineness, were found to protect the legs alike from cold and heat. Stockings and gloves of this production, however thin, are too warm for common wear, but are esteemed useful in gouty and rheumatic cases. This great warmth of the byssus, like the similar quality in silk, results probably from both being imperfect conductors of heat as well as of electricity.

It is not probable that this material will ever be obtained in much abundance, or that it will cease to be a rarity, except in the places of its production. It is never seen in England save in the cabinets of the curious.

The appearance and general characteristics of the produce of the pinna, the spider, and the silkworm, are so similar, as to have acquired for them one generic name. If all their constituent parts be alike, it forms another among the numerous subjects for surprise and admiration, excited by contemplating the wonderful works of nature, that the same silky principle can be alike elaborated from the fish, the fly, and the mulberry leaf. *

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* Note EE.

PART III.

ON THE MANUFACTURE OF SILK.

CHAP. I.

REELING.

ARRANGEMENT OF FILATURE. — SEPARATION OF DIFFERENT KINDS OF COCOONS. — DESCRIPTION OF REEL. — MANNER OF REELING. — CONSTRUCTION AND PROPORTIONS OF REEL REGULATED BY LAW IN PIEDMONT. — PRECAUTIONS. — SIZE OF THREADS. — REGULATION OF TEMPERATURE. — WASTE SILK. — QUANTITY REELED IN A GIVEN TIME. — MODE OF ASCERTAINING FINENESS OF THREAD. — SPUN SILK. — FLEURET. — FRENCH INFERIOR TO ITALIANS IN THE ART OF REELING. — REGULATIONS AND RESTRICTIONS IN PIEDMONT. — THEIR OPPRESSIVENESS AND IMPOLICY.

In countries where silk is produced, the winding of cocoons is generally pursued as a business distinct from that of rearing the worms; and the silken balls become an article of trade so soon as the insect within has been deprived of vitality by some one of the means already described. Sometimes, indeed, this process also is left to be performed by the purchaser.

The building designed for a filature should be lofty; open on one side and accessible to the rays of the sun, while it is walled on the other side as a shelter from cold winds. A free passage should be afforded to the steam arising from the boilers, which vessels should be disposed in rows on either side of the building; by which arrangement the superintendant can readily overlook the whole number.

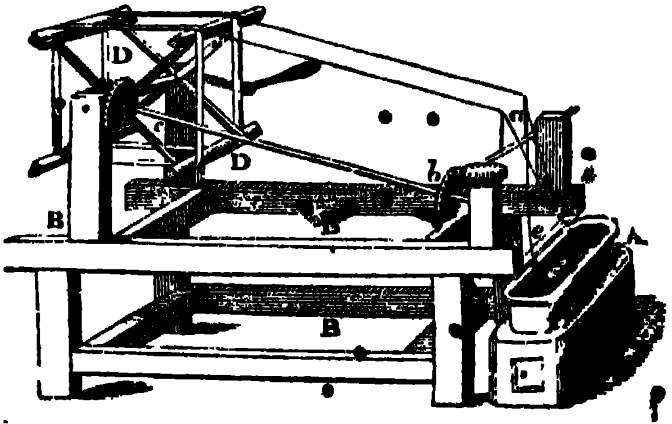
Before the cocoons can be reeled, it is necessary to separate them from their outward floss. This is very expeditiously done by opening the floss at one end, and protruding the cocoon, or hard, compact ball, which is to be reeled.

Although previously to selling his cocoons the vender is by law obliged to separate the soufflons and perforated cocoons from the others, there will yet always remain some of these, which, added to the dupions and choquettes, amount to about ten per cent. of the whole number. It is of great consequence that the cocoons should at this time be carefully classed, according to their qualities, as each separate class requires a different treatment in reeling, both as regards the heat applied and the rapidity of winding.

Good cocoons, white as well as yellow, are the easiest wound. Cocalons call for the greatest care and skill: they require to be placed in cooler water than the others, and then, in the hands of an expert winder, as good silk may be produced from them as from the rest. Experienced reelers must likewise be employed for dupions and choquettes, which both require the application of hotter water than good cocoons.

In Piedmont, where silk of the best quality is produced, the process of reeling has long been conducted by the employment of a machine similar to the drawing here given.

Fig. 7.



A is a copper boiler about 18 inches long, and six inches deep, set in brickwork, so as to admit of a charcoal fire being made beneath it: if other fuel be used, a small flue or chimney must be added to carry away the smoke. B B is a stout wooden frame whereon the several working parts of the reel are supported. D represents the reel on which the silk is to be wound; *a* is the layer which directs the position of the threads in their passage to the reel; *b c* is the wheel-work which gives motion to this layer. The reel D is merely a wooden spindle, turned by a crank handle at one end, and having four arms mortised at each end within the frame. These arms support the four battens or rails on which the silk is wound. The rails, which are parallel to the axis, are placed at such a distance from it, that they may produce a skein of proper size by the winding of the silk upon them. They are usually so disposed as to pass through the space of one yard at each revolution. One of each of the two sets of arms is made with hinges to fold in the middle of its length, in order that the rail which these two arms support may fall in or approach the centre as occasion may require: this, by diminishing the size of the reel, allows the skeins of silk to be readily slipped off when the winding is completed.

At the end opposite to the handle of the wooden spindle, and within the frame B, there is placed a wheel with twenty-two teeth, giving motion to another wheel *c*, which has about double that number of teeth, and is fixed on the end of the inclined axis *c b*; this, at the opposite end, has a wheel *b* of twenty-two teeth, which gives motion to a horizontal cog-wheel of thirty-five teeth. This last wheel turns upon a fixed pivot in the frame, and has, near to its periphery or outer rim, a pin, to which the wooden rail or layer *a* is attached. The opposite end of this rail plays in a mortise or opening made in the frame B. This layer is furnished at equal distances from the frame with two wire loops or eyes, through which the silk threads are passed in being wound. Now, if motion be given to the horizontal cog-wheel by means of the other wheels and inclined axis, when the handle of the reel is turned, it is evident that this will cause the layer likewise to move to and fro, directing the threads which pass through its wire eyes alternately to the right and left, through a range equal to the diameter of the horizontal cog-wheel to which it is attached.

The iron bar *e*, which is fixed over the centre of the boiler, is pierced with two holes, through which the threads are led in their passage from the boiler to the layer.

If the thread of each cocoon were reeled separately, it would, from its extreme tenuity, be wholly unfit for the purpose of manufacture: several threads are therefore reeled together. The cocoons which are to be wound being put into the hot water contained in the boiler A, the gummy matter which they possess is softened, so that the unwinding of their threads is facilitated, and at the same time the fibres, which are brought together in the reeling, adhere, and form one strong and smooth thread.

In the process of reeling, as often as the thread of any single cocoon breaks, or comes to an end, its place is supplied by another; so that the same number is continually kept up, and a thread of the same substance may be continued to any length. The single filaments which are thus from time to time added are not joined by tying, but are simply laid on the compound thread to which they will adhere by their gum, and the ends being extremely fine do not occasion any perceptible unevenness in the spot whereon they are laid.

It is of considerable importance that the water wherein the cocoons are put should be either rain water, or that which is obtained from ponds or slow running streams. That denominated hard water, which is supplied by springs and from wells, usually contains a large proportion of earthy salts, and will not sufficiently soften the gum, so that the threads would be liable to continual fracture.

Fire being applied in the furnace, the water in the boiler A is brought nearly to the point of boiling. The exact degrees of heat to which the water should be raised do not appear to be particularly defined, but are ascertained only by the effects produced, and are regulated according to the experience of the reeler. If the silk comes off in knobs or lumps, which are not fully extended, it shows that the water is too hot: it must be immediately cooled, and the fire abated. If, on the contrary, the silk is with difficulty drawn from the cocoons, which is known by their often bounding from the boiler, the water is then evidently not hot enough sufficiently to soften the gum, and the fire must be increased.

Two or three handsful of cocoons are thrown into the boiler, wherein they are submerged during some minutes to soften their viscidity. The reeler then takes her seat at the side, and gently presses the cocoons with a brush of about six inches long, made of the finest twigs, or tops of heath bound together, and cut off evenly at their ends. By this operation the loose threads of the balls adhere to the brush, and are drawn out by its means, when the reeler disengages them, and draws their ends through her fingers to clear them from any loose flossy silk. These preliminary steps are called the *battue*. The ends of four or more of the threads thus cleared — their number of course regulating the fineness of the silk intended to be wound — are passed through each of the holes in the iron bar *e*. After this, two of these compound threads, consisting of four or more threads each, are twisted twenty or more times round each other, in order that the filaments may better unite together by these mutual crossings, and likewise that the whole may assume a cylindrical form, as without this twisting the silk would be wound flat on the reel. After being thus passed through the iron bar *e* and twisted, the threads are led through the wire eyes of the layer, and being thence conducted to the reel are made fast to its rails. A boy or girl is now employed to turn the handle of the reel: this must be performed with a regular even motion, and somewhat slowly, until it is ascertained that all the cocoons yield their threads freely. As soon as this is ascertained to be going forward satisfactorily, a much quicker motion is given to the reel.

This speed is, however, regulated by the reeler according to certain indications. If the cocoons should bound from the water the motion must be slackened, and if knobs or lumps appear, which show that the silk is yielded by the cocoon more rapidly than taken up by the reel, its rotations must be accelerated. It is the province of the reeler to observe these signs, and to regulate accordingly the heat of the water and the celerity of the winding.

The slow traversing motion of the layer prevents the threads from lying over each other on the reel, until they have made so many revolutions through the air as to dry the gum of the silk sufficiently to prevent the adhering of the threads together. The sizes of the wheels and the numbers of their teeth are so regulated, that after the reel is covered for about the breadth of three inches by the gradual progression of the layer, half a revolution of the horizontal cog-wheel will have been made, and thereafter the layer will necessarily return and direct a second course of threads over those first laid; and so on, until the entire length of silk proper to form the skein has been wound.

The machine winds two skeins at the same time, which it is evident cannot by this arrangement in any way interfere with each other.

It is considered essential to the production of good silk, that the thread shall have lost part of its heat and adhesiveness before it touches the bar of the reel. For this reason, the Piedmontese reelers are obliged by law to allow a distance of 38 French inches between the guides *a* and the centre of the reel. The motion of the layer is also regulated, and must be moved as here shown by a cog-wheel, instead of by an endless strap, which is sometimes used in other of the Italian states, and which if suffered to grow slack will slip without moving the layer; the threads will consequently not lie distinctly and regularly, and the skein will be gummed together; whereas the regularity of the cog-wheels cannot be interrupted. When the skeins are finished, the reel is removed from its frame, and after being set to dry they are taken off by folding the arms provided with hinges. Each skein is at this time generally tied round in two places with some of the refuse silk, and it should also be slightly gummed in one part, but not so much as to occasion its adhering together strongly; a sufficient quantity causes the skein to preserve its regularity; too much gum would occasion the thread to break in the throwing mill. The silk is then doubled into a hank, and is considered ready for use or sale.

Although the process of reeling is apparently very simple, yet some attention and skill are required for the production of an even thread. The reeler must not wait until the thread of a cocoon is entirely exhausted before she puts on another, because as they approach their termination the filaments become much finer. It is necessary to attend to this circumstance, as well as to the breaking of the threads, that the requisite degree of substance may be preserved throughout. This gradually decreasing thickness of the fibres is in such a proportion, that where half wound cocoons, previously broken, are again added, two such are considered equal to one that has not been used. Thus the union of three new and two half wound threads are equal to silk of four cocoons.

The balls must not be wound off to the last, because when they approach their termination, the husk of the worm, or *bairré*, is carried forward with the thread and makes the silk foul. When the silk is nearly wound off, the chrysalis will drop through, and the ball being then too light to continue in the boiler, will rise to the iron bar *e*, and if not immediately removed would, by stopping the passage, occasion the breaking of the whole thread.

In giving a proper degree of attention to all these particulars, the reeler will find unceasing occupation. She must, besides, be always prepared with new ends of cocoons to replace those which break or come to an end; and from time to time it is necessary to throw an additional supply of cocoons into the boiler for this object. Even this little point requires to be done with judgment;

for, if any of the cocoons should remain too long in hot water, their gum would be dissolved, and the silk would come from them unequally. The balls when in the boiler must be frequently pressed under the water, that their whole surfaces may be equally wetted: if this is not attended to, the principal part of each ball would, from its buoyancy, remain dry and stubborn, while the portion immersed would be too much softened.

Silk may be wound of any size, from one cocoon to one hundred; but it is difficult to unite more than thirty in one thread. The art consists in winding an even thread; for as the filament of each ball is not of one uniform tenuity throughout, the skill of the reeler is required so to arrange and bring the threads together, that the same thickness may be continuously preserved throughout the skein. This perfect equality is so difficult of attainment, that the degree of substance in the silk is never exactly defined; and, with the exception of a thread of two cocoons, which is so called, silks are not distinguished as those produced from three, four, or five fibres, but are said to be of three to four, four to five, or five to six cocoons. Coarser skeins are not even so nicely defined; but are called from twelve to fifteen, from fifteen to twenty cocoons, and so on.

The reeler must always during the operation of winding have at her side a bowl of cold water, wherewith she may from time to time, as occasion arises, abate the heat of the water in the boiler. It is not of more consequence to the facility of reeling, than it is to the quality of the silk produced, that the water should be of proper temperature. If too hot, the thread proves what is technically called *dead*, and is without firmness; and should there have been a deficiency of heat, the ends will not be well joined, and the silk will be harsh. A thread cannot without difficulty be wound when only cold water is employed; and the adhesion of the fibres of which it is composed is so slight, that the thread breaks by the application of the smallest force, and the least moisture will separate its filaments: those of silk wound from hot water cannot be separated except by the same agency.

When the reeling of the skeins is finished, the boiler X must be cleaned; all the chrysalides which have been stripped of their covering must be removed, together with such cocoons as still retain a portion of silk. These latter must be thrown into a basket, into which the loose silk which is disengaged in making the *battue* is likewise placed: these are considered as waste silk, and must be carded and spun in order to form threads. The water in the boiler must be changed four times a day when dupions and choquettes are wound. If only good cocoons are reeled, twice is considered often enough for its renewal. The chrysalides and husks contained in the cocoons very speedily make the water foul: it is therefore that these frequent changes are needed; for if the water employed be not tolerably clear, it will be in vain to look for the production of fine glossy silk.

The weight of silk that can be reeled in any given time is governed by the degree of quickness wherewith the reeler can add fresh ends for broken or expended cocoons. It makes little difference whether twenty cocoons are united to form one thread, or the same number be employed to produce four skeins, provided both descriptions are wound with an equal regard to evenness and good quality. There is a degree of dexterity required in adding the ends, which can only be acquired by practice; and very few reelers are sufficiently expert to give the necessary attention to three skeins at the same moment.

A woman experienced in the business of reeling, with the assistance of a girl to turn the wheel and attend to the fire, can with ease wind off one pound of silk, consisting of four to five cocoons, of the most perfect quality, in one day. Two skeins are wound upon her reel at the same time; when these are completed, they are set in the shade to dry, without being removed from the reel, which, for this purpose, can be readily disengaged from the frame. These two skeins will occupy the morning's labour. In the afternoon a fresh reel is employed, and two other skeins are wound, which again are set apart until the morning, that they may be dry before removal from the wheel. Where silk of more ordinary quality is wound, one person can as easily attend to the reeling of four, six, or even more skeins, placed at the same time on a machine of larger dimensions. A coarse, foul, and ordinary silk will be the produce, six or eight pounds of which may be obtained by one day's labour of a woman and her young attendant.

When skeins of silk thus completed become articles of sale, the fineness of their thread is determined by means less liable to deceive than the unassisted eye of man. A reel so constructed, as that the circumference of the skein when wound upon it shall be of a certain known admeasurement, is made, to perform a given number of revolutions, usually 400, when the skein is removed and accurately weighed. The comparative weights of silk, whereby their fineness is denoted, are estimated in weights called deniers, twenty of which are equal to sixteen and a half grains.

It is evident that the smaller the tendency of the threads to break the greater is the proportion of work that can be accomplished by the reeler; and this forms one among the many reasons for choosing sound and good cocoons.

The breaking of the single filaments arises principally from using ill-formed cocoons, and from the improper regulation of the heat of the water. The silk of dupions is so interlaced that it perpetually breaks, rendering these the most troublesome and unprofitable of any quality for winding.

The whole thread is sometimes broken in its passage from the cocoons to the reel, through the stopping of the loops in the layer by knobs as before described, or by the reel being turned with a jerking motion. Even in this case, however, the silk does not require to be rejoined by a knot, but is sufficiently attached if the parts, on being brought together, are slightly twisted.

Evenness of thread, and the absence of knobs or knots, which among manufacturers give to silk the name of being foul, are the leading points which determine its value. The best mode for judging whether silk be *clean* is to open the skein, and look down upon it in the same direction with the light. By this examination any foulness which exists will be readily perceived, and a very little practice will enable a person, by a mere *coup d'œil*, to judge with accuracy upon the essential qualities of the silk.

Royal cocoons, which are those which have been pierced by the breeding moths, are never reeled, but are spun with the soufflons and perforated cocoons. These are all boiled in water, the soufflons for half an hour; perforated cocoons somewhat longer; and royal cocoons for a full hour. The latter kind are opened while yet damp; the other two descriptions are first dried and then beaten to disengage them from their chrysalides, which are reduced to a powder. The cocoons thus prepared are placed on a distaff, and opened by taking each end and drawing out the fibres at arm's length. The produce of these balls, when worked, is called *fleuret*. If after boiling and beating the cocoons are carded, the fleuret will be more beautiful and of a brighter colour, but of a higher price, owing to the waste which attends this operation. It is considered a very tolerable day's work for a good spinner to complete one ounce of fleuret. Of this description of silk, royal cocoons produce the best, next the perforated cocoons, and, lastly, the soufflons. A very inferior kind of silk is also produced by spinning the coarse floss and the refuse of the reeling.

Although those cocoons from which the moths have been allowed to escape are always consigned to the hands of the spinner instead of the reeler, it would appear from the testimony of one who took much trouble to ascertain the point, that great part, at least, of these, might be advantageously wound. "I have," says the reverend Mr. Swayne, "taken the pains to unravel the cocoons after the insects had left them, and I found that the thread was not discontinued in any one instance, unless when I broke it myself. It was often so much entangled that I could not proceed, yet sometimes I have wound off nearly the whole cocoon. If put in water, the silk will be immediately entangled." One year this gentleman bred one hundred worms, and allowed them all to pierce their cocoons: he was able to wind off fifty of these, which weighed exactly one hundred grains, and the waste silk for spinning which remained after the reeling weighed thirty-three grains.

Information obtained from an accurate and very intelligent observer, leads to the conclusion that the establishments for reeling silk in France are much inferior in their arrangements to those of Italy. The principal cause assigned for this inferiority is the want of some general regulations, which in some measure would control the mode of conducting the process. It is said that the Piedmontese silk owes the reputation it has so long enjoyed, and which it continues to sustain, to regulations imposed by the government at an early period after the introduction of silk cultivation into that country, and which are still very strictly enforced. The tendency of these regulations is not only to obtain good silk, but to procure also regularity in *size*, and uniformity in the working of the machines employed for reeling. The proprietor of a silk filature in Piedmont before he commences the business of reeling, is obliged to announce to a local board of commissioners the number of boilers he intends to use, and the thickness and weight of silk which he means to produce in the season. A smaller quantity than five hundred pounds' weight of silk is not allowed to be reeled in a single filature. The various establishments are visited, during the season of reeling, by the members of the commission; and should any person be found operating upon a greater or lesser number of cocoons than he has previously reported, or otherwise in any way infringing the regulations, a fine is imposed. Nothing of this kind exists in France; and in consequence there is found an infinite variety in the size of the reel and the thickness of the silk. Some wind off their cocoons with cold water, some with hot, and others again use steam for softening the tenacity of the balls.

Most cultivators of silk in France reel the cocoons they have produced, even although these should not weigh more than twenty pounds. In many places the reelers are paid according to the weight of silk wound, and without reference to its quality; a system which naturally tends to carelessness and improper haste, as well as to the production of only the coarser qualities of the material. In this case, the number of fibres continually being wound renders it impossible to supply deficiencies with sufficient quickness and regularity; and, as a necessary consequence of this defective process, the silk is wasteful and irregular, demanding in all the after-stages of its manufacture much additional time, labour, and expense.

There are exceptions to this faulty manner of conducting the process of reeling in France, and particularly in the department of the Gard; the produce of some filatures in that district being considered nearly equal to the best of Italy. The silks produced in Ardèche, and on the left bank of the Rhone, are coarser, and less carefully reeled. As an exception, however, there is produced a superior description of white silk in the upper part of the department of Ardèche, which is purchased by the lace manufacturers of Normandy, and which sells for more than 50 *f.* per pound: a few years back it commanded as high a price as 150 *f.* per pound.

In a letter published in the *Précurseur* of Lyons on the 5th of February, 1830, and which is understood to express the opinion of the best informed merchants and manufacturers of that city on the quality of French grown silk, there is much valuable information to be found on the subject of the silk trade. It is stated in this letter, that, with the exception of the produce of some filatures in the department of the Gard, and of one or two others, destined to be converted into organzine by the proprietors themselves, and whose interest consequently leads them to bestow the requisite degree of care, none of the silk of France possesses the desirable regularity of fibre which distinguishes the silk of Briance.

Previously to its undergoing the process of throwing, the raw silk of France is submitted to examination and selection, in order to class the different descriptions found in the same parcel. This is both a tedious and expensive work, which is wholly unnecessary when employing Italian raw silk.

The interference of the Piedmontese government, as above mentioned, may, at first view, appear to have been beneficial to the silk trade of that country, and, so considered, might lead to the belief that similar intermeddling would be equally advantageous to France: the soundness of this opinion may, however, be doubted. The effect of the regulations described is to create a monopoly in the hands of large and wealthy proprietors at the expense of the poorer cultivators, who are unjustly restricted from the conversion of their own produce, and are therefore unable to derive all the advantage that might attend upon their labour. The effect of this, and of every other kind of oppression, is to destroy the springs of industry, and consequently to diminish the annual produce.

In France, the small farmer employs, probably, the least efficient part of his family, in a pursuit which somewhat promotes their worldly advantage, but which, under restrictions similar to those imposed by the Sardinian government, would not offer sufficient inducement to command his attention. Having reared a few thousand silkworms, he is not restricted for the sale of their raw produce to one or two wealthy proprietors of filatures, whose interests would lead them to combine together and depress the price of his produce; and although, for a time, his attempts at reeling may fall short of the perfection of the art, this is the lesser evil of the two, and one which, in the nature of things, must diminish. The powerful spur of interest, which is wanting in the other case, is continually inciting him towards proficiency, that he may turn his industry to the greatest profit; and the principle appears incontrovertible, that individuals will always judge better for themselves on such subjects than any government can judge for them.

CHAP. II.

THROWING.

ART BROUGHT FROM ITALY. — IMPROVEMENTS SINCE MADE. — SINGLES. — TRAM. — ORGANZINE. — BOILING TO DISCHARGE GUM. — ITALIAN THROWN SILK. — REASONS FOR ITS SUPERIOR QUALITY. — HIGH PROTECTING DUTY ON IMPORTATION. — REDUCTION THEREOF. — IMPROVED QUALITY OF ENGLISH THROWN SILK. — GREAT EXTENSION OF THE BUSINESS. — IMPROVEMENTS IN THROWING MACHINERY NOT ADOPTED ABROAD. — LOW WAGES THE OCCASION OF THIS. — EXPENSE OF ORGANZINING. — WASTE IN THE PROCESS.

It has been already shown, that the English throwsters were indebted to Italy for their knowledge of a most material part of the art of preparing raw silk for the weaver, and that the mills first erected for this purpose by Messrs. Lombe at Derby in the year 1718 were copied from machinery then used in Piedmont. The English reader, who has been accustomed to watch with admiration and pride the progress of ingenuity among his countrymen, will not be surprised to learn, that the throwing mills then erected, although justly, at that time, the objects of admiration, are now rendered obsolete by improvements subsequently made. On the other hand, in the country whence our enterprising countryman first drew his plans, the same arrangements are continued to the present day, without improvement or alteration of any kind. Even in France, where the silk manufacture has long been one of the staples of the country, and where there is no deficiency of either ingenuity or enterprise, no improved machinery had, up to a very recent period, been erected for the preparation of organzine, although it forms one of the most important materials used in the production of most of their fabrics, and is one of indispensable necessity in some branches of the manufacture. It is believed that, to the present moment, the whole of the organzine used in France for the manufacture of their best fabrics, continues to be drawn from the other side of the Alps.

Raw silk, before it can be used in weaving, is made to take one of three forms, being converted into either singles, tram, or organzine.

The first, which is the most simple process, consists in merely twisting the raw silk, in order to give more firmness to its texture; and, in fact, during its progress towards the formation of the two other preparations, raw silk must pass through the intermediate state of singles.

Tram is formed by twisting together, not very closely, two or more threads of raw silk, and this description most commonly forms the weft or shoot of manufactured goods.

The formation of organzine, which is principally used in the warp, that is, to form the length of the goods, is a more elaborate performance, and requires a more detailed description than the two former, in giving which, it is hoped, that a correct idea may be also communicated of the preparation of tram and singles.

To do this, it is scarcely necessary to attempt the description of machinery on an extended scale, since the requisite explanations can be given with greater clearness, and with equal correctness, by means of the simplest mechanical arrangements. With this view, all notice of the recent improvements which have been adopted in the most considerable throwing mills will be suspended, until the simpler operations which preceded those improvements have been detailed. Not that there is, in reality, any complexity in even the most elaborate engines for throwing silk, but to any person not much accustomed to the examination, or conversant with the uses, of machinery, the mere exhibition of numerous cranks and shafts crowded into a narrow space, and giving motion to a multiplicity of wheels, has a tendency to confuse the mind, and to create an appearance of complexity and confusion, where, in truth, all, when well understood, proves to be beautifully distinct and simple.

In the descriptions that will be found in this volume, of the various processes used for the preparation of silken threads, and for their conversion into useful fabrics, as well as in all explanations of the various mechanical contrivances whereby these processes are effected or simplified, the use of all technical terms is as much as possible avoided. Where these occur, as sometimes they must, in order to avoid prolixity or unnecessary repetitions, such explanations of their meaning and value will have been previously furnished, as, it is hoped, will preserve the general reader from imbibing those false conceptions and impressions, which never fail to bewilder the mind, and thus render it difficult to acquire any clear comprehension of the subject.

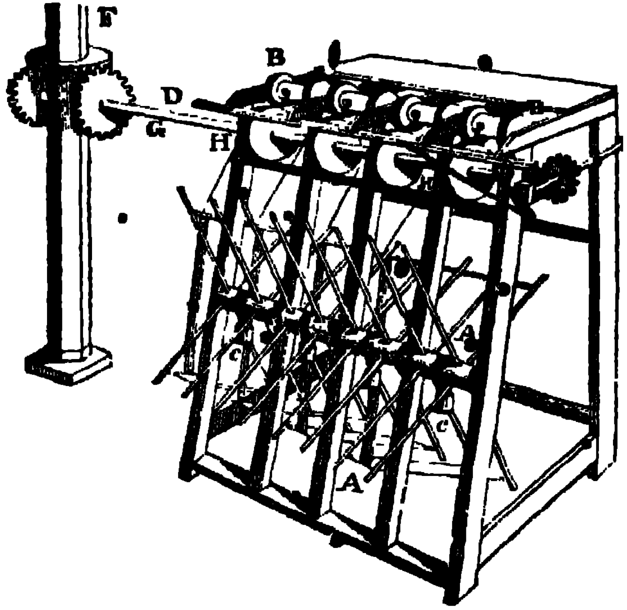
The operations which raw silk undergoes in its progress towards organzine may be divided into six distinct processes.

1st. Winding it from the skeins, upon what are called bobbins, in the winding machines.
2d. Sorting it, when so wound, into its different qualities.
3d. Spinning or twisting each individual thread in the mill.
4th. Bringing together upon fresh bobbins, two or more threads already spun or twisted.
5th. Twisting these two or more threads together by means of the mill.
6th. Sorting the skeins of twist or organzine, according to their different degrees of fineness.

The first operation, that of winding the raw silk, used always to be performed by means of a winding machine, the construction of which may be easily understood, if reference is made to the diagram here given. The machines commonly used for winding are continued to a considerable length, so as to wind a great number of skeins at the same time, but to simplify this description only a part of the machine is drawn, the remaining parts being only reduplications of that which is given.

Each skein of raw silk must be extended upon a slight reel A A, which is called a swift. It is formed of four rods fixed through an axis, so as to form a sort of double wheel of eight spokes, which are so disposed that four of them make right angles with each other

Fig. 8.

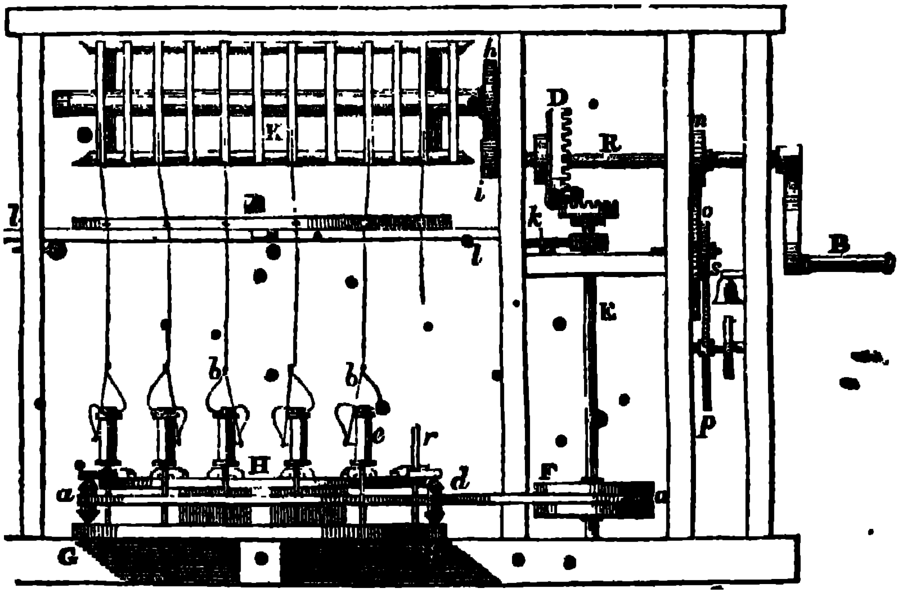


and stand opposite and parallel to the four spokes of the answering part of the wheel. These parallel spokes are then connected together by bands of string, thus forming a kind of lantern wheel; and the bands can be so placed as to vary the effective diameter of the wheel, in order to suit exactly the size of the skein to be fixed upon it. This provision is rendered necessary by the circumstance, that the raw silk of most countries is wound so as to be equal in circumference to a yard, according to the standard measure of the country; and as some difference exists in these standards, the reel which would suit the silk imported from one quarter would, without some such provision, be unsuited to that of any other country.

The swifts may be made to revolve freely upon wire pivots; but as it is needful to wind the silk from them, and to deliver it upon the bobbins, with an uniform degree of tension, simple means are employed for creating the necessary amount of friction, either by means of a spring or by hanging a looped wire upon the axis withinside the reel. To this loop a small leaden weight is attached. B B are what are called the bobbins; these are made of wood, and consist of a hollow axis, on each extremity of which is fixed a circular disc, the uses of which discs are to cause the revolution of the bobbin, in a manner which will be described, and to confine the silk upon the hollow axis. These bobbins can be easily placed in or withdrawn from the frame. D is called the layer. This is a light wooden rod, having wire eyes fixed in it, one opposite to each bobbin; through which eye the end of the thread upon the reel is passed when it is attached to the bobbin. This layer has a lateral motion communicated to it, by means of a crank fixed upon the cross spindle E, which crank is turned by two bevelled wheels fixed at the end of the horizontal spindle G. The whole is put in motion by the bevelled wheel on the upright shaft F, which is connected with another bevelled wheel on the spindle G. This, revolving, carries with it the wheels or discs H H; and the discs of the bobbins resting upon these are carried round by the friction caused by their own weight, and occasion, consequently, the delivery of the silk from the reels upon the bobbins. The motion of the layer causes this delivery to be uniform over the axes of the bobbins. The constant attendance of children upon this winding machine is requisite, in order to join the ends of any threads which may be broken in winding, and when the skeins are exhausted, to place new ones upon the swifts. When the bobbins are filled, they are lifted out of the frame, and empty ones are placed in their stead, to which the skeins being attached, the operation is continued. During the time occupied in renewing the skeins upon the swifts, or of removing and replacing the bobbins, the process is still continued with the unexhausted swifts and unfilled bobbins, each being in that respect independent of every other.

The third operation, that of spinning or twisting the thread thus wound upon the bobbins, is performed with the throwing mill. The particular construction of this mill is frequently varied, but the principle of its action being always the same, it would be useless to describe more than one of its modifications. Mills of great power and considerable extent are generally used for this purpose in England, but on the continent it is by no means unusual for artisans to purchase raw silk, and to employ their wives and children in preparing it for weaving. The machines which are then used are necessarily small, and are turned by hand; from the form in which it is usual for them to arrange the spindles, the apparatus is called by them the oval. This throwsting mill is now chosen for description in consequence of its simplicity.

Fig. 9.



The number of spindles which it contains is thirteen, and of these, to avoid confusion, only six are shown in the diagram; the remainder would be arranged behind those which are seen. Upon each of the spindles the hollow axis of a bobbin, before described, is placed, so that the bobbin has liberty to turn freely upon the spindle. Upon each spindle, just above the bobbin, a piece of hard wood is so fixed by a pin as to cause the wood to revolve with the spindle. To this wood is fixed a piece of wire called a flyer, *b*, bent in the form here given. At each extremity of the flyer an eye is formed; of these the lower eye stands opposite the middle of the bobbin, and the upper eye is exactly over the centre and a few inches above the top of the spindle. The thread from the bobbin is passed through both these eyes, and also through another wire-eye, fixed in an oval frame L, which has a traversing motion to and fro, communicated to it by means of a crank, or an eccentric pin, *k*. This is fixed in a cog-wheel, turned by a pinion upon the perpendicular axis E, the end of the rail *l* being supported upon a roller, to cause its more easy and regular motion, so that the threads are guided with regularity to the reel K, in the same manner as by the layer to the bobbins in the winding machine before described. Motion is communicated from the crank B to the spindles, by means of a wheel D, connected with a pinion on the upper end of the vertical axle E, which also, at its lower end, has a drum F to receive the endless strap or band *a a*. This encompasses the oval frame G, and gives motion to all the spindles, being so confined by the rollers *d* and *a* as to press with the requisite degree of force upon the spindles, and to give to all of them an uniform celerity.

It is now evident, that every revolution of the spindle and flyer must give a twist to the thread drawn from the bobbin. Whether the twist shall be hard or slack depends upon the comparative celerity of the spindles and bobbins, and this proportion is regulated by the relative sizes of the wheel *h* and the pinion *i*, whence the reel and bobbin receive their motion. For different manufacturing purposes silk must be thrown or twisted with different degrees of hardness; this is provided for by the power of changing the wheel and pinion *h* and *i* for others of different proportional diameters.

For the purpose of clearer elucidation, one of the spindles is shown without a bobbin, while the rest are all mounted, and supposed to be in action. The skeins upon the reel should be made to an uniform length, and this is attained by a train of wheels consisting of a pinion *n* fixed on the principal spindle R, turning a wheel *o*, which has a pinion fixed to and turning with it, giving motion to a larger wheel *p*. This, again, has another smaller wheel upon its spindle, with a pin fixed in it, so that at every revolution it raises a hammer and strikes upon a bell *s*, whereby the attendant has notice of the quantity wound on the skeins.

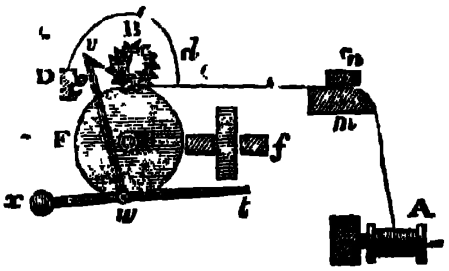
When the machine is employed for the first operation of twisting raw silk for organzine, which requires a strong and close twist, the wheel *h* must be of greater and the pinion *i* of less diameter than are here represented, in order that the reel K and the bobbins may receive a slower motion, in proportion to the speed of the spindles.

The silk is now in the form of singles, the only difference between which and the single twist in course of preparation for organzine, besides the degree of hardness noticed above, is, that in the latter process the crank must be turned in an opposite direction, so as to give a reverse motion to the machinery. Organzine silk is of the nature of rope, where the combined strands are twisted in an opposite direction to that given to the separate threads, whereas singles and tram are twisted only in one direction, similarly to twine, or to the individual strands of which the larger rope is made.

When silk is intended to be dyed in the skein, the twisting in this machine is but slight, and its direction must of course depend upon its ulterior destination, whether for tram or for organzine. Silk thread intended for organzine is, in this first operation, twisted in a left-hand direction.

The next operation is to bring two, three, or more of these twisted threads together upon one bobbin. The number of the threads depends of course upon the substance which it is intended to give to the organzine, and a careful sorting of the threads must be made, so as to bring together such only as are of an uniform texture. To effect this, a machine is used, very similar to the winding machine already described. Instead of gathering the silk from the bobbins on a reel in its first twisting in the throwing machine, when the object is to prepare organzine, it is usual to transfer it to other bobbins. In the operation of doubling, these bobbins are placed in front of the winding machine, where, of course, they take the place of the swifts, and stand two or three or more in a row, according to the number of strands to be subsequently brought together in the organzine, in the manner shown by the following figure.

Fig. 10.



The threads in the bobbins are passed over one and beneath another wooden rail *m* and *n*, with both of which they are brought in close contact. These rails being covered with cloth serve to cleanse the silk in its passage, equally well with the less artificial means offered by the fingers of the person employed in winding.

In their passage or transference from one set of bobbins to the other, each thread passes through a small piece of wood *e*, which slides freely up and down in a mortised hole through the fixed board *f*. The use of these slides, which are equal in number with the threads to be brought together, will soon be seen. All the threads are then passed through the wire-eye *d* of the layer D, which it is more convenient to place behind the bobbin, causing the wire to be bent over it, as shown in the figure. The bobbins to be filled, rest upon, and take their revolving motion from the wheels F, as in the winding machine. The degree of tension given to the silk threads in winding causes them to raise the sliders *e*. Should any one of the threads break, the slider through which it passed, no longer supported by it, strikes upon the bent lever *t v*, which, moving upon its centre *w*, causes the hook *v* to catch into the notches made for that purpose in the disc of the bobbin B, and this immediately stops its motion. The winding of the required number of threads thus proceeds with as much certainty as the winding of one would do. It is the business of the attendant to repair the broken thread, when the slide *e* being again raised, the weight *x*, attached to the bent lever *t v*, raises the end *t*, frees the notched bobbin from the hook *v*, and the machine is once again in motion.

The bobbins, thus filled with double or triple threads, are once more carried to the throwsting machine, and are there spun or twisted together by an operation similar to that already described, with the sole difference before mentioned, of giving a reversed direction to the spindles and flyers. In this operation, the silk, now converted to organzine, is transferred to reels instead of bobbins, and then, being made up into skeins, is sorted for sale or use. Previously to this, however, and in order to prevent its crinkling when removed, a tendency to which it has acquired in the twisting, the reels are subjected for two or three minutes to the action of steam, which is found effectually and permanently to set the twist. This is a modern improvement; it having formerly been the practice to steep the reels in boiling water, a more tedious and less effectual operation. The degree of hardness given to the twist is varied according to the purpose for which it is intended, and depends, as already described, upon the relative diameters of the wheel and pinion *h* and *i* of the throwsting machine.

The silk thus thrown is called hard silk, and must be boiled in order to discharge the gum, which otherwise renders it harsh to the touch, and unfit to receive the dye. The silk is boiled for about four hours in a plentiful proportion of water, into which a quantity of soap, equal to about one third of the weight of the silk, has been placed; this assists in dissolving the gum, and in rendering the silk soft and glossy.

By this boiling, the silk, which has already in the previous operations of organzining lost in the proportion of from five to seven and a half out of each one hundred pounds of its weight, is further diminished to twelve, and sometimes to eleven and a half ounces for every pound. Considerable carefulness is called for in this operation, to prevent injury to the threads from burning, which sometimes will occur, and occasion material loss to the manufacturer, or to the dyer, to whom the process is intrusted. If, by reason of the viscid gum contained in the silk, the skeins adhere to the bottom of the copper in which they are boiled, the heat is, by that means, necessarily intercepted in its passage to the water, and accumulated in the silk, which is in consequence partially carbonised and spoilt. Even when the injury thus occurring to the staple of the thread is less apparent, it frequently discovers itself when put into the loom, causing infinite trouble and delay to the weaver, who often, in such a case, cannot weave in a working day of twelve hours more than, in the absence of injury to the silk, he would have woven in half that time, and the injury to him is therefore one of very serious consequence.

After this boiling, the silk is well washed in a current of clear water to discharge the soap; and when subsequently dried, although its weight is so sensibly diminished, its bulk is, on the contrary, visibly increased, and it is seen to have acquired that peculiar glossiness and softness of texture which form its principal and characteristic beauty.

The gum which has been now discharged served the useful purpose of causing the adhesion of the fibres, as originally wound from the cocoons. This end is now more effectually attained by the twist the thread has received in the throwing mill; and the gum would henceforth be considered as a foreign matter, impairing the beauty and destroying the flexibility of its texture. Were the boiling performed before the twisting, this operation could scarcely be at all completed, and at best only an entangled woolly or downy substance would be obtained, wholly unfit for manufacturing purposes. Before a thread of useful texture could be then got, the silk would require to be spun by some process similar to that followed with cotton wool, or such, indeed, as is necessary with the waste silk drawn from the cocoons in the first operation of reeling, and with those cocoons which are injured or reserved for breeding, and which it is found difficult or impossible to wind in the filature.

It has always been asserted, and, if the assertion be correct, it is a curious fact, that, notwithstanding the great advantage of superior machinery, the English throwster is unable to produce organzine silk equal in quality, and at as small an expense, or with as little waste, as that prepared in Italy. It was long held, and is still believed by many, that the Italian throwster, who is also most usually a dealer in silk, reserves the finest qualities for his own operations, and exports only that which is inferior. Supposing, however, that the difference in the value of the thrown silk is such as is stated, it is perhaps nearer to the truth to believe that the climate may influence the quality of a substance so delicate, since it is well known that, during certain states of the atmosphere, the throwing of silk is performed in this country at a comparative disadvantage. . Or it may be, that the fibre of the silk is injuriously affected by its being packed before twisting, or by the lengthened voyage to which it is subjected in its transit to this country; and the higher estimation uniformly evinced by our throwsters for silk of the new crop, over that which has lain for some time in the warehouse, would seem to indicate another cause for the alleged superiority of Italian organzine. It is owing to this preference of foreign thrown silk, that, in the face of a high protecting duty, it has always met with a certain, although limited, demand from the English silk weaver. Prior to the year 1824 this protection in favour of the English throwster amounted to more than nine shillings per pound; and when, by the removal of all save the merely nominal duty of one penny per pound on raw silk, such a spur was given to this branch of the manufacture, that the quantity of silk thrown in England was doubled, the importation of foreign thrown silk, although burdened with a duty of seven shillings and sixpence per pound, was not diminished, but rather the reverse. This impost in favour of the home throwster was afterwards reduced to five shillings, and subsequently, in the year 1829, to three shillings and sixpence per pound, without any material alteration in the quantity imported following these abatements. These facts must be held to confirm the correctness of the belief, that foreign organzine is, to a certain extent, and in some branches, necessary to the operations of the weaver, who, therefore, will purchase it, whatever may be the duty wherewith it is burdened; so that, in truth, any impost would be nearly inoperative as a protection to the English throwster, while it would constitute a considerable hardship to the weaver. It is certain, however, that this preference of Italian thrown silk is fast disappearing; and there are now many among the principal English manufacturers who make use of English thrown silk exclusively for the manufacture of every description of goods.

The act of parliament, which was passed in the year 1824, whereby the duty on raw silk was all but abolished, and that on thrown silk was so materially reduced, occasioned, as has already been remarked, considerable animation among the silk throwsters, who for some time experienced great difficulty in keeping pace with the demands of the manufacturers. This state of things naturally led not only to a great extension of their establishments, and to the erection of new throwing-mills in various parts of the country, but called likewise the attention of ingenious men to the improvement of machinery already employed in the processes of throwing, and to the proposing of new modes of effecting these processes. It does not appear, however, that any new and material invention has hitherto been brought into use in throwing machinery; the improvements effected being, with some comparatively immaterial exceptions, confined to the more perfect formation and execution of machinery already invented. The rude wooden wheels and drivers which were long used have now given place to well constructed cast-iron gearing; the old rough wrought-iron spindles are now superseded by others of steel, accurately turned; and metallic bearings have been substituted for the barbarous wooden shoulders with which the throwsters were formerly contented. The consequence has been, that at a less expense of power the spindles have been made to revolve with treble and even fourfold speed; thus economising time, machinery, and labour.

Hitherto these improvements do not appear to have found their way across the Channel; and the French and Italian throwsters are still contented if their spindles revolve 300 to 400 times in each minute, while ours are performing commonly 1800, and sometimes even 3000, gyrations in the same space of time. Our French rivals are fully aware how greatly the English throwsters are in advance of them in this particular, but they have not the same inducement that exists in this country to incur a heavy first expense in alterations, that they may secure a prospective advantage. From the lower wages paid for labour in that country, such advantage would not be in any proportion to that realised by our manufacturers. Wherever the wages of labour are highest, there always will be found the greatest encouragement for the exercise of ingenuity in abridging its amount. The wages paid in Lyons to men employed in silk-mills does not average more than six shillings and sixpence per week; and the earnings of women and girls, who, taken together, form five sixths of the number of hands employed, scarcely exceed three shillings per week, for which pittances the whole are required to labour fourteen hours *per diem*.

The French throwsters have another disadvantage. They are dealers as well as manufacturers, buying the raw silk and selling their organzine through brokers to the silk-men. The mills being situated in the centre of the silk-producing district, their purchases are made from country farmers, who bring to market only small quantities, seldom more than fifty, and most generally not exceeding ten pounds of raw silk in a parcel. On this account the throwster must incur additional labour and expense in sorting the skeins, so as to produce a tolerably regular thread of organzine. In this they frequently succeed but indifferently; and the consequent disadvantage in their sales is poorly compensated by the two or three per cent. which they reckon upon gaining in the weight from the draught of the scale in making so many small purchases.

The expense of organzining in France, as ordinarily conducted, is said not to exceed two shillings and ninepence to three shillings per pound, including the loss from waste. MM. Chartron, *père et fils*, at St. Vallier, whose silk establishment is reputed to be the most extensive in France, and who conduct the manufacture in all its various branches,—reeling from the cocoons, throwing, and weaving,—estimate the expenses of the throwing processes higher than the price here mentioned. They convert their raw silk into organzine for use, and not for sale, and consequently may be supposed to employ more carefulness in the operations than is bestowed in other establishments differently circumstanced, drawing a more than equivalent advantage therefrom in the greater facility which accompanies the subsequent stages of their manufacture. Where the requisite degrees of attention have been bestowed in reeling, sorting, and throwing, the French grown silk is undoubtedly of very fine quality, being fully equal to the Italian. The French manufacturers themselves give a preference to the production of their own soil and industry.

The charge made at present in the neighbourhood of London for organzining Italian silk is about five shillings and sixpence per pound, the throwster taking upon himself, out of this price, to make good to the merchant the value of the waste, whatever it may prove. If the owner of the silk is content to bear this loss of weight, the throwster will abate one shilling per pound of his charge. The waste varies materially in silk produced from different filatures, and is much greater with that brought from

Italy than is incurred with the East India company's importations from Bengal. The loss sustained in the processes of throwing this kind of silk is said sometimes not to exceed two per cent. upon the weight of the raw material; thus giving evidence of the great degree of carefulness which has been used in the original reeling of the cocoons.

In a throwing-mill situated in the neighbourhood of London, which has been recently erected, and where due attention has been paid to the fitness of the machinery, there are 1600 swifts employed, with a proportionate number of spindles. These are all put in motion by a steam engine, on the high-pressure principle, of six-horse power, having a boiler of capacity equal to the production of steam for an engine of double that force. The surplus steam is employed in warming and drying the factory. In this establishment, which is very carefully and ably conducted, there are employed 120 people, mostly young girls; and the quantity of silk thrown during the whole year, the works being constantly employed, is about 12,000 pounds' weight. The weekly performance varies somewhat according to the quality of the material under conversion, and also with the hygrometric state of the atmosphere; for which reason the yearly working is stated, rather than fall into any unintentional misrepresentation by giving the result of only one week's operations.

CHAP. III.

PLAIN WEAVING.

ANTIQUITY OF THE ART. — INVOLVED IN OBSCURITY. — LITTLE IMPROVEMENT IN WEAVING APPARATUS. — INDIAN MANNER OF WEAVING. — SIMPLE LOOM. — MODE OF ITS ACTION. — WARPING MACHINE. — MOUNTING THE LOOM. — SHUTTLE. — METHODS OF WEAVING. — RIBAND WEAVING. — ENGINE LOOM.

The art of combining and interlacing fibrous substances with a view to the formation of cloth is of the very highest antiquity, so that its origin is involved in deep obscurity. It is impossible to adjudge to any one people the merit of its first discovery: it is indeed highly probable, that many communities might, with perfect justice, lay claim to this merit. The same wants, and the possession of nearly similar means for their gratification, might naturally lead to a discovery of the method whereby those means could be rendered available. The testimony of almost every traveller who has explored new regions acquaints us with the fact that weaving, in some form or other, has been invented and pursued in almost every country, where the inhabitants are led by the nature of the climate to seek protection for their bodies from its inclemency.

It is probable that in its earliest form, weaving consisted merely in the intermixture of substances which had undergone little or no previous preparation. That the first invented cloth was composed of rushes, or straws, or of shreds of the bark and fibrous parts of trees or of plants, which needed not the previous operation of spinning. It must have formed a most important epoch in the progress of any country, when its inhabitants first came to the knowledge, that some among those fibrous substances were capable of being so united by twisting as to form continuous and unbroken threads, whose strength allowed of their taking the place of ruder materials.

The obscurity wherein the whole art of spinning and weaving is involved prevents the formation of any opinion concerning the first adoption of silk among the substances employed in this manner. In the east, the high antiquity of the pursuit of rearing silkworms has already been established; and it would form a very useless subject of speculation to enquire how soon, in that portion of the globe, this pursuit followed the discovery of the weaver's art. It is well known that among European nations the weaving of linen and woollen cloths was practised and brought to a considerable state of advancement before they arrived at any knowledge of the existence of such a substance in nature as silk; when, therefore, fabrics wrought from this curious and beautiful filament first appeared among the Greeks, it found them prepared, as has been shown, to re-model the costly substance into draperies of more moderate expense; and when, at a still later period, the unwrought material was obtained, there was no longer any difficulty in converting it to purposes at once of usefulness and embellishment.

The machine employed for enabling the weaver to perform his labours has, up to very recent times, been the object of but little change or improvement. In England, where mechanical science has long been made the handmaid of the arts in almost all branches of industry, every improvement which has been introduced in the mechanism of the loom is comparatively recent; and for many of these improvements we have been indebted to foreign invention, rather than to the contrivances of native ingenuity. Looms exactly similar, both in form and arrangement of parts to those which have been used time out of mind by the weaving craft, are still to be seen in daily occupation, preferred even, for every purpose to which they can be made available, by the labouring artisan.

Simple as are these looms, they can yet be favourably contrasted with the rude contrivances still pursued in

India, where the wretched weaver performs his labours in the open air, choosing his station under trees, whose shade may protect him from the scorching rays of the sun. Here, extending the threads which compose the warp of his intended cloth lengthwise, between two bamboo rollers, which are fastened to the turf by wooden pins, he digs a hole in the earth large enough to contain his legs when in a sitting posture; then, suspending to a branch of a tree the cords which are intended to cause the reciprocal raising and depressing of the alternate threads of his warp, he fixes underneath, and connected with the cords, two loops, into which inserting the great toe of either foot he is ready to commence his operations. The shuttle, wherewith he causes the cross threads or woof to interlace the warp, is in form like a netting needle, and being somewhat longer than the breadth of the warp, is made to perform the office of a batten, by striking the threads of the woof or shoot close up to each other.

With this rude apparatus the patient Indian succeeds in weaving fabrics, which, for delicacy of texture, cannot be surpassed, and can hardly be rivalled by the European weaver, even when his labours are aided by the most elaborate machinery. But it is only in climates where the absolute natural wants of man are few, and under systems of government where the oppressions of the dominant caste deprive the unhappy bulk of the people of all means for attaining more than suffices for the barest supply of those wants, that such labours can be so performed.*

The art of weaving varies but little, whatever may be the material which is the subject of the manufacture. The principal difference discernible in the construction of looms intended for the weaving of silken or of woollen fabrics consists in the greater strength and stability required for the latter machine, in consequence of the less delicate nature of the substance employed.

The simple loom, ordinarily used in weaving plain silks, is similar to the following representation: —

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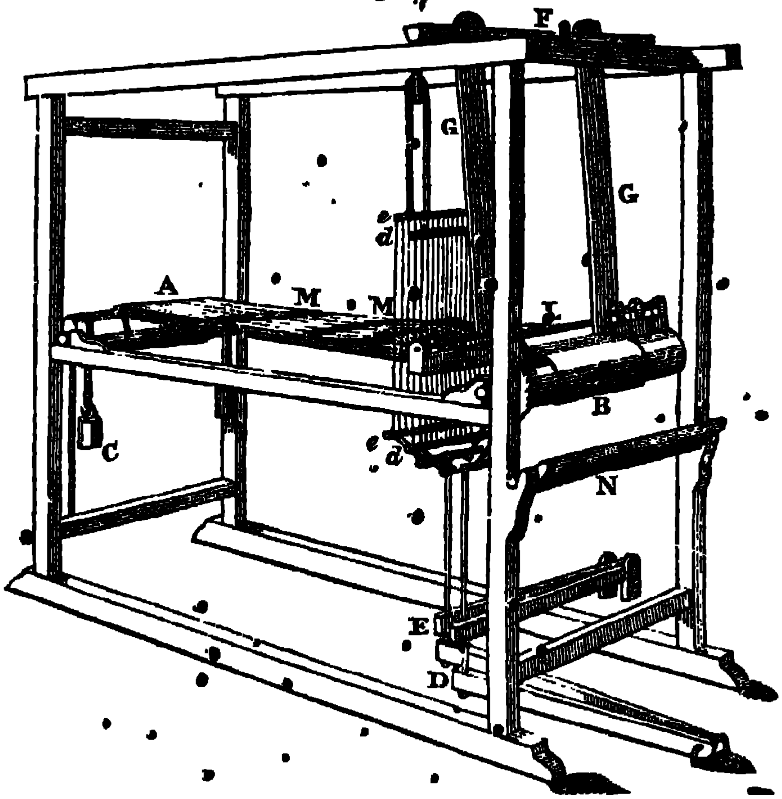
* Note F F.

A is the beam or yarn-roll, on which the threads which form the warp are wound, after being regularly spread in a manner which will be described; B is the cloth-beam or breast-roll, to which the ends of the warp are also attached, and on which the woven silk is wound when finished; C is a weight attached to the frame of the loom, and suspended over the yarn-roll to produce, by the friction of its cord, the requisite tension of the threads of the warp; D E are treadles, on which the weaver presses his feet alternately; and, as the treadle D is attached to the heddle * or harness *d d*, while the other treadle E is attached to the heddle *e e*, it will be evident that the depression of each treadle will correspondingly influence the position of its heddle. The two heddles *d d* and *e e* are each formed of two horizontal sticks, connected through their whole extent by nume-

Fig. 11.



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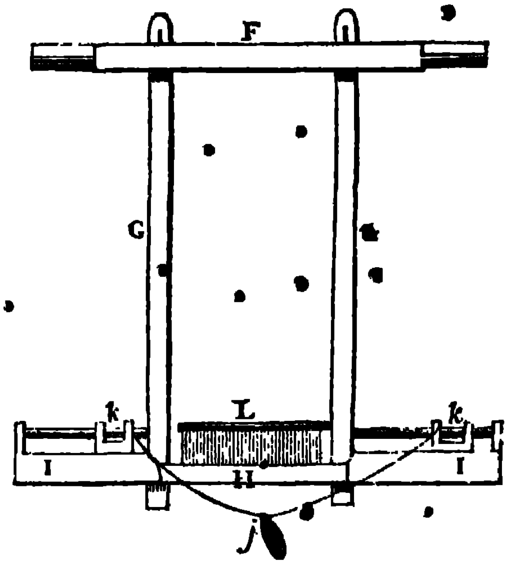
* This part of the apparatus is known in some parts of the country by the name of Healds, in other places, as in London, the weaver uses the distinctive name of Lames, but as that of Heddle appears to be most generally applied, the latter name will be used preferably in this volume.

rous small cords of an equal length; and the two heddles are so united by a rope and pulley, as shown in the drawing, or by any other convenient apparatus, that the depression of one must cause the raising of the other. These heddles, which are commonly called the harness of the loom, are furnished with loops at the points where they will be intersected by the warp, each individual thread of which is passed, in regular succession, through the cords of one or other of the heddles, so that each alternate thread of the warp is passed through the loops of the one heddle, while the intermediate threads are passed between the cords of that one, and through the loops of the other heddles. It is now evident that the depression of the heddle *d d*, by means of the treadle D, will cause the depression of all the threads of the warp which pass through its loops, and at the same time will raise the heddle *e e*, together with all the intermediate threads of the warp which pass through its loops, leaving, between the two divisions of threads, a space of about two or three inches, which is called the shed, for the passage of the shuttle. A modern improvement substitutes for the loops small metallic eyes, through which the warp threads are passed, and by this means the wearing of the threads is in some measure avoided: these eyes are called mails. The frame F G G H is called the batten or lay, and for greater clearness is shown by a separate drawing.

This batten is suspended by its bar F from the upper framing of the loom in such a manner that it will swing to and fro as on a centre of motion. A shelf, called the shuttle-race, is formed by making the bottom bar H broader than the side rails G G, so that it projects about an inch and a half beyond them on the side furthest from the breast roll. The ends of this shuttle-race are prolonged by boards, which form troughs or boxes I I, in each of which is placed a piece of wood or thick leather, K K, called a pecker or driver, and these drivers are made to traverse on small guide wires fixed between the side rails G G and the ends of the troughs I I.

The drivers are united by a slack string fastened to each, and meeting at the handle *j*. L is the reed which is composed sometimes of small portions of split reeds or canes, but most frequently of flattened steel or brass

Fig. 12.

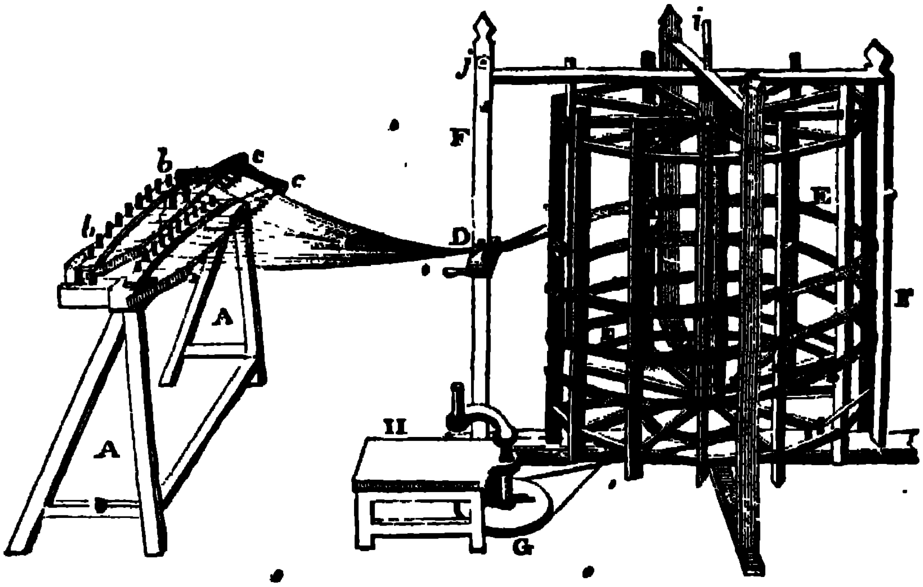


wires. These are fixed, like the teeth of a comb, in a frame which rests upon the shuttle-race H, and the threads of the warp are passed through the interstitial spaces of the reed. These are covered by a top piece, having a longitudinal groove along its lower side, and which is called the lay-cap. M M (*fig.* 11.) are cylindrical bars of wood made smooth, which are placed horizontally between the alternate threads of the warp, to prevent their becoming by any means entangled. Sometimes three of these sticks are used, and then one of them is inserted in the shed and drawn to its proper station, while the threads of the warp are actuated by one treadle, and the other two are introduced when the other treadle is depressed. By this means a longitudinal crossing of the threads of the warp is effected which renders them still less liable to entanglement. N is the weaver's seat, and being hung by rounded ends, resting in corresponding brackets fixed to the framing, the position of this seat accommodates itself to the convenience of the weaver in the different movements of his labour. It must be lifted out when the weaver either takes or quits his seat at the loom, and can be readily replaced.

The operation of warping is one which must be performed with careful accuracy, as an uniform tension of each thread of the warp is essential to the perfection of woven fabrics. Some conception may be formed of the carefulness required in this part of the weaver's labour, when it is considered that a piece of fine silk, whose width is not greater than twenty inches, frequently has the breadth of its warp made up of more than eight thousand threads, each one of which must be so accurately disposed in its proper station as to avoid entanglement or confusion throughout its whole extent. In former times, this operation was effected by extending the threads at length in a field, in which manner it is still performed in China, and by the native weavers in India. It was a considerable improvement when, instead of this tedious process, a frame was employed on which the threads were extended and wound backwards and forwards over pegs. This mode, however, was still very tedious, and therefore expensive, besides requiring a ceaseless vigilance on the part of the persons employed to preserve the regularity of the threads. To meet these evils, the warping machine, which will now be described, was invented.

A A is a tressel, upon which are placed a number of bobbins *b b*: these are arranged in rows; and it is usual to wind together the contents of forty-six bobbins. The thread from each of these is drawn over a wire *c c*, and passed through a perforated piece of wood D, whence the threads are conducted altogether to the large reel E E. This is supported in a frame F F, and it turns by means of a fixed pulley placed at the lower extremity of its vertical axis, whence an endless band passes to the groove of the horizontal wheel G, which is fixed to a spindle and turned by a handle, as shown in the drawing. A child seated upon the stool H gives motion to this wheel, and sets the whole in action, drawing the threads from the bobbins, and transferring them, assembled together, to the warping machine. In order to distribute the warp over the reel, the perforated piece of wood D is so attached to the upright post F of the frame, as to slide freely upon it, and being suspended to

Fig. 43.



the spindle *i* by a cord, which passes over the pulley *j*, the rotations of the spindle by winding upon itself and therefore shortening this cord raises the piece D so as to distribute the warp evenly, in a spiral form over the surface of the reel, without one part lapping upon another. When the requisite length is reeled off the bobbins, the threads are tied together and cut.

The warp is now composed of threads of an equal length, and when drawn from the reel is wound into the form of a ball in readiness for the *cane spreader*, or *turner on* to fix, or mount it in the loom. As the warp is required to be of a greater length than the reel contains when one spiral has been wound upon its surface, the threads are then turned over studs placed at the top and bottom of the reel for that purpose; and a reverse motion being given to the reel, the wooden piece D sinks gradually by the unwinding of the spindle *i*. The threads are then delivered from the bobbins, and laid off, in a descending spiral upon the reel; and this operation may be again reversed and repeated until a sufficient length of warp is obtained.

In mounting the loom, that is, in fixing the warp preparatory to the commencement of actual weaving, the first operation is to roll regularly upon the beam, or yarn-roll, the different portions of warp threads thus brought together, and which are known by the weavers as *portees*, and this is called beaming. To effect this, two or more persons must be employed. The instrument used for the purpose of guiding the threads of the warp, and of spreading them regularly upon the yarn-roll, is called a separator, or ravel, and is, in form, very similar to the reed already described, being made of a number of shreds of cane, or of wire fastened together in a rail of wood, in the shape of a comb. These ravels are made of different dimensions to suit different descriptions of work. Between these teeth, or reeds, the threads of the warp are placed, and are there confined by a top-piece similar to the lay-cap of the reed, and which in this case is called the cape. The threads of the warp being separated and guided by means of the ravel, one or two persons keep the threads at their proper degree of tension, while another winds them on the yarn-roll, by turning it on its centre.

The next process is *drawing*, or entering, which is passing each thread of the warp regularly through its appropriate loop in the heddle. To effect this, the weaver places himself in front of the heddles; and opening the following loop of each heddle in succession, takes the threads from a person standing behind the heddles, whose business it is to select and deliver them in their proper order, when they are drawn through the loops. The warp thus drawn through the heddles is passed through the interstitial spaces of the reed by the assistance of a small hook, called a sley, several threads, according to the texture of the goods, being passed through each interval of the reed, but an equal number of threads being inserted between each opening, with the exception of the twelve outer or marginal *dents* or wires, through which an increased number of threads are passed, in order to form the selvage of the goods. The reed is then placed in the lay or batten; the ends of the warp threads are knotted together in several portions, which are tied to a shaft, and this being connected by cords to the cloth-beam, and the threads being stretched, the warp is ready for weaving. The weaver, whenever able to do so, simplifies this operation of drawing or entering, by connecting the threads of his new warp, or cane, with the threads of the warp just on the point of being finished. This, of course, saves the labour of passing the new threads through the mails and the dents of the reed, since they must then follow regularly those to which they are attached. To distinguish it from the original entering of the warp through the heddles, the weavers give the name of *twisting on* to this expedient, which saves them seven eighths of the expense they must otherwise incur in mounting the loom.

The shuttle is formed from a piece of boxwood, varying in length from three to six inches, and is pointed at

Fig. 14.

each end: it has in its upper side an oblong cavity, for the purpose of receiving a hollow cane, which, however, is always called a quill, probably because quills may have been usually employed in former days for this purpose; upon this the silk to be used in forming the shoot is wound; a metal wire being passed through the hollow of the quill forms its axis, about which it must revolve freely when inserted in the shuttle.

The quantity of silk wound upon each of these quills is necessarily but small, and their frequent renewal is indispensable. For this purpose, the shuttle has in its cavity two small holes, one in the centre of each end, for the insertion of the points of this axis. One of these holes has a spring concealed within it, which, by its compression, allows of the insertion of one end of the wire to a depth sufficient for admitting the other end to enter the opposite hole; and when this is so inserted, the spring prevents its spontaneous withdrawal, while it offers no impediment to the next changing of the quill.

The only art required in winding the quills is to provide that the silk shall be delivered freely from them: the best form for this purpose is found to be that of a double cone. The winding of these quills is usually intrusted to young children. There is a hole in the side of the shuttle communicating with the cavity, and furnished with an eye of glass, to prevent the cutting of the silk in its passage; through this hole, the end of the silk is drawn by the weaver, who so places it with his finger, that, applying his mouth to the eye, and drawing in his breath, the silk is forced through by the current of air into his mouth.

The weaver now places himself in the seat of the loom, and leaning lightly against the cloth-roll places his feet upon the treadles. In his right hand he takes the handle of the string attached to the two drivers, and his left hand holds the lay-cap or cover of the reed. The shuttle being placed in the trough against one of the drivers, and between it and the warp, the weaver commences his operation by pressing down with his foot one of the treadles: this depresses one half of the threads of the warp, while it raises the others. He then gives a pull, or rather a jerk, to the handle of the driver, in such a manner that the shuttle is thrown by it through the shed or opening between the threads of the warp into the opposite trough, and against the other driver, leaving behind it the thread which is to form the shoot. The batten being then pulled by the left hand towards him, the shoot, which was lying loose between the warp, is, by means of the reed, driven up towards the cloth-roll. The other treadle being now in its turn depressed, the operation is reversed; the alternate threads of the warp change places, and the shuttle is again thrown, by another jerk of the driver, into the same position in the opposite trough which it first occupied. The batten, which had returned by its own weight to its vertical position, is again pulled towards the cloth-roll, and, by a constant repetition of these movements, the weaving is effected. When the labour has been continued long enough to complete a few inches of woven cloth, this is wound upon the cloth-roll, the rotations of which are effected by means of a short lever inserted for that purpose into holes made at the right-hand end of the cloth-roll, and this end being furnished with a serrated or ratchet wheel, a pall or click falling into its teeth, prevents the roll returning. The woven silk is kept at its proper degree of extension by small hooks, called templets, connected with strings which pass through pulleys at either side of the loom, and are connected with weights at their other extremities.

Plain weaving is thus seen to be a very simple operation. A certain degree of proficiency in the art may doubtless be quickly and easily attained, but much practice and attention are nevertheless required, in order to form a dexterous weaver, so as to enable him to produce well woven fabrics, and to accomplish within a given time such a portion of work as will earn for him a competent subsistence.

Many tyros in the art so use their feet as to depress the treadles far too suddenly; the bad consequence of which is, that by the sudden relaxation and tension of the threads of the warp, such among them as may at any point be weak are broken, the tendency to which accident is increased by the greater friction against the dents of the reed. Considerable time is then lost in renewing the broken threads; frequently more than would have sufficed, in the absence of such accidents, for the actual weaving of the goods. The evil is still greater if, through inattention, the shuttle is kept at work after the breaking of one or more warp threads. Broken threads cannot, of course, retain their relative position with the rest, but cross over or become interlaced with others, to the manifest injury both of the look and actual quality of the fabric. Frequently, too, these broken threads interfere with the passage of the shuttle, and occasion farther mischief by the breaking of other portions of the threads.

If the motion given to the shuttle be more than sufficiently rapid, it will strike too forcibly against the opposite driver, and by its recoil will slacken the thread of the shoot, upon the due tension of which much of the beauty of the fabric depends.

It is also of importance that the batten should be brought forward against the shoot with an equal degree of force at each stroke, otherwise there would be no uniformity in the thickness of the cloth. A knowledge of the degrees of force proper to be applied to fabrics of different natures and degrees of fineness can only be acquired by attention and long practice. An experienced weaver always endeavours so to mount his loom, that the batten shall have such a range or swing as is proportioned to the texture of the goods under preparation. The motion of the batten, as it swings to and fro, is similar to that of a pendulum tracing the arc of a circle, and the greater or less extent of this arc determines the greater or less degree of force wherewith the shoot is driven home; for which reason it is of importance that the woven cloth should be very frequently taken up or wound on the cloth-roll, lest the uniformity of its texture should be interrupted by the diminished range of the batten. In weaving coarse or thick goods the batten should be hung so as to give it greater play, and consequently more force, than where fine and light fabrics are woven.

Many experienced weavers continue to use the ancient mode of passing or throwing the shuttle through the shed of the warp from one hand to the other, rather than adopt the use of the drivers. In this case, both hands of the weaver being occupied in passing the shuttle, the batten is weighted, so as to fall with the proper degree of force against the shoot; and when the batten has performed this office, it is made to resume its proper position by means of whichever hand may in turn be at liberty. This method seems preferable to the one already described, where the weight is applied so as to draw the batten away from the web, to which latter it must then be brought by the hands of the weaver; a mode which seems liable to more than one objection. The force applied to the batten cannot be so constant a quantity under the manual operation of the weaver, as when effected by an unvarying weight, especially where the use of the fly-shuttle is not resorted to, and the change in the action of his hands from the throwing of a shuttle to the pulling of a batten must increase the toil of the weaver more than is caused by merely pushing the batten so as to allow the passing of the shuttle. If, too, the force is applied preferably to one side of the batten, the shoot will be more closely driven there than on the opposite side, and the work, in consequence, will not prove equally perfect. In weaving goods of great breadth, the fly-shuttle may be considered as an indispensable instrument, and indeed it would seem that nothing but the preference acquired through habit, can occasion the employment of the ancient shuttle rather than of this. There can be no doubt that, for an operation to be effectually performed by one hand, where two would otherwise be indispensable, must give the workman a greater command over other parts of his operations.

When fine goods are woven, the loops of the harness would be very inconveniently crowded together, if two heddles only were employed. It is customary, therefore, in such cases, to use four, six, or even more heddles; but this causes no alteration in the action of the loom, the heddles being made to work in pairs or sets, called leaves of heddles, where all composing the same leaf are raised and depressed by the same treadle.

It is of consequence that looms should be erected of a true rectangular form, or the work will otherwise be all awry and unsightly. It is likewise important that the loom should be substantially made and firmly fixed, to prevent any tremulous motion in its working, which would cause the same evil, by producing an unequal tension of the warp.

The weaving of plain ribands is usually performed in a loom which enables the weaver to operate upon several lengths or warps at the same time; the number of these varies, being seldom under eight or beyond twenty-eight. The apparatus whereby this is effected, and a drawing of which is here given, is called the Dutch Engine Loom, a name which sufficiently indicates its origin. It is worked by the hands, and with treadles for the feet, in the same way as a common loom; each warp occupies a separate shuttle, which, unless the weaver were furnished with as many arms as Briareus, cannot, it is evident, be passed from hand to hand. The apparatus for impelling the shuttles to and fro is, owing to a resemblance in its form to that implement, called a ladder. This ladder slides horizontally in a groove made in the batten; and the whole being put in motion by the reciprocating action of a handle situated near the middle of the lay-cap, each cross-bar of the ladder is made to strike in the manner of a driver, alternately right and left, upon one of the two shuttles between which it is placed. These engine looms do not require any yarn-roll or cloth-roll. The warps hang over pulleys, in loops which are weighted, and the ribands being similarly disposed, are carried away as they are woven. This movement is precisely regulated by causing the batten to strike against blocks placed on the upright posts of the framing in front of the loom, so that the progress of the batten being prevented beyond the requisite point, the shoot is driven home in the web with the exact degree of force which is proper. The same impulsion, assisted by the weights, drives the woven fabrics in minute portions, as they are completed, over the pulleys, and draws the warps forward in the same degree, so that the only interruption from his work experienced by the weaver is when the weights have run through the range assigned to them. The finished ribands are then wound up, and fresh lengths of warp unwound; the weights are again applied as at first, and the weaving recommenced. Some of these engine looms are so constructed as, by the addition of a simple mechanism, to render even this interruption unnecessary; the woven ribands being wound, and the warps unwound, in proportion as the weaving goes forward.

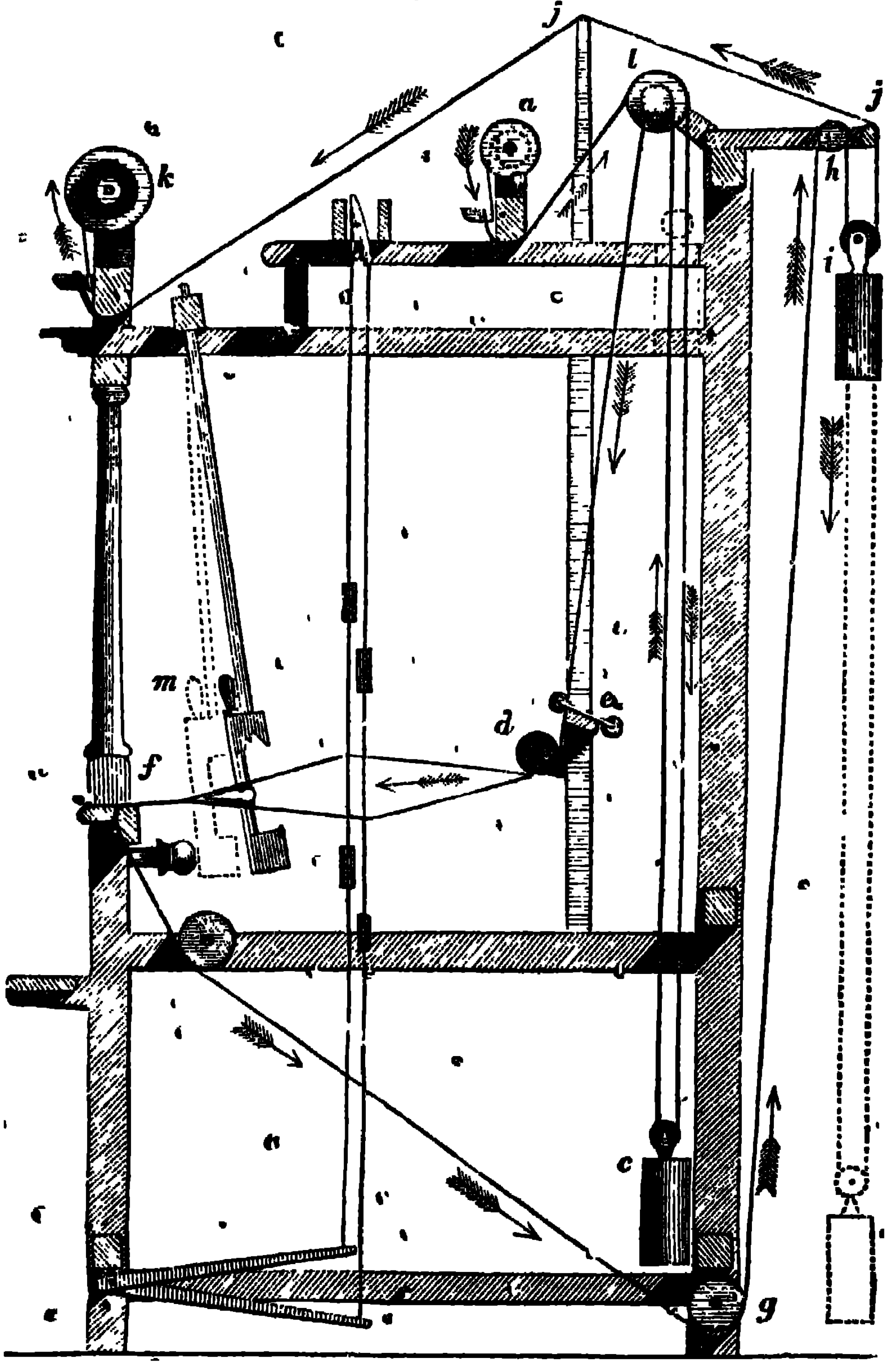
With one of these looms a diligent workman may weave one yard in an hour of as many narrow ribands as the loom is qualified to produce at the same time.

a is one of the bobbins upon which the warps are wound, and which, therefore, in part perform the same office as the yarn roll in a common single loom. From these bobbins, the warps pass over the pulleys *b*, each of which has close to it, and at its side, a smaller roller or pulley. Over these the warps are again turned after being extended by the weights *c*, one of which is suspended to each warp. From these smaller pulleys it will be seen that each warp descends to the horizontal roller *d*, which is on a level with the shuttle-race. This roller has attached to it a series of reeds or sleys *e*, similar in construction to those contained in the batten; and these additional reeds, one of which is used for each warp, are needed in this case, because the proper and regular spreading of the warps has not been previously or otherwise accomplished.

The arrangement of the heddles, the passage of the warps through them, and the action of the batten with its attendant lay-cap and reeds, are similar to the like parts and motions in common looms, with this exception, that the warp from which each individual riband is formed passes through the dents of a distinct reed.

The course by which the woven ribands are carried away may be traced through rollers in the rail *f*, which stands in the situation usually occupied by the breast-roll in front of the weaver. Thence the ribands pass diagonally to other rollers *g*, in the bottom rail of the back framing of the loom, and rising perpendicularly, they are carried again through pulleys *h* to other pulleys furnished with weights *i*, and thence over the top rails of the framing *j j* to bobbins *k*, placed in the front of the

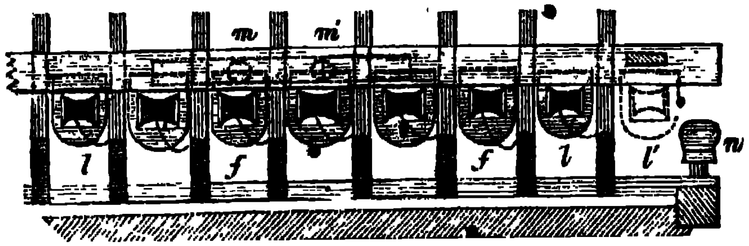
Fig. 15.



loom, over the head of the weaver, who, from time to time, as already mentioned, winds up thereon the finished riband.

The lay-cap and shuttles are here shown in a separate drawing. *l l* represent the shuttles, and *m* the handle, by the reciprocating action of which the shoot is made. This handle moves in a horizontal slot or groove, which

Fig. 16.



is covered by a piece of wood connected to and moving with the handle. The lateral movement of this handle to the position shown by the dotted lines *m'*, effects the throwing of the shuttles, which then take up their positions on the sides of the warps opposite to those which they before occupied, as is also shown by dotted lines *l'*: the next return movement of the handle *m* carries all the shuttles back to their original positions: *n* shows the situation of the blocks which regulate the striking up of the shoot by the batten, as has been already described.

The engine loom is chiefly used in Coventry, which has long been the principal seat of the riband manufacture of England; giving employment to beyond 10,000 looms, of which about one third only are what are called single looms, that is, constructed for the weaving of one breadth only. These last are mostly employed in the manufacturing of figured ribands, while the engine looms are generally occupied with plain goods.

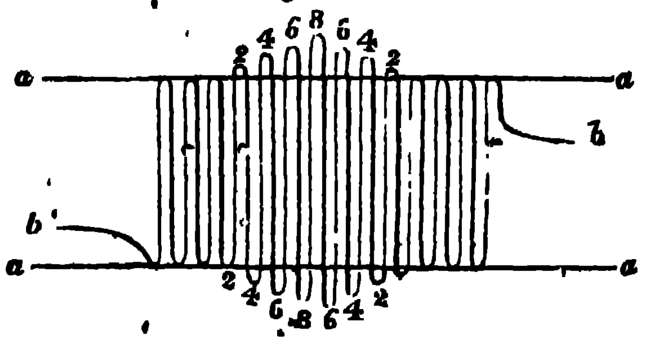
The Coventry weavers have made so very marked an improvement in their art since the legalised importation of foreign manufactured silks, that one of the most eminent manufacturers of that city has declared, that he should, at this day, blush for the work which even his best hands used formerly to furnish; that now their patterns and productions are fully equal to those of their foreign rivals, and qualified to come in successful competition with the most beautiful ribands wrought by the Lyonnese weavers.

Ribands are frequently ornamented by having what is called a pearl-edge given to them. This is formed by causing portions of the shoot to project beyond the edges of the riband, and the extent of these projections is so governed as that they shall assume a symmetrical appearance, according to the particular form required, whether as vandykes, or scallops, or any other figures. This pleasing effect is produced by employing supplementally to the warp-threads, and outside each edge, a certain number of horse-hairs, which pass through mails in the harness in the same manner as the warp-threads, but which hairs will be drawn out of the riband by the act of its being wound on the roller. The horse-hairs are so connected with the machinery of the loom as to be raised in the succession proper for forming the pattern required.

The following diagram exhibits the mode of forming the simplest sort of pearl-edge.

The lines *a a* represent the edges of the riband; *b b* the shoot, and the figures 2, 4, 6, 8, signify the number

Fig. 17.



of hairs which have been included in the several threads of the shoot to which the numbers are attached, in order to form the pearl-edge. It will be seen that, by varying the order of succession used for raising the horse-hairs, the form of the edge will be determined in the particular manner that is desired.

The commoner sorts of ribands, are composed altogether, both warp and shoot, of Bengal silk. Those of better quality are manufactured with a mixture of Italian and Bengal silk; and the finest descriptions are made of Italian silk without any mixture. Riband is woven in pieces, each of which measures thirty-six yards.

CHAP. IV.

FIGURE WEAVING.

SUMPTUARY LAWS. — ANTIQUITY OF ORNAMENTAL WEAVING. — STRIPES. — CHECKS. — CHANGES OF COLOURS. — TWILLS. — DRAW-LOOM. — DRAW-BOY. — JACQUARD MACHINE. — PRINCIPLE AND MODE OF ITS ACTION. — CARD-SLIPS. — ADVANTAGES OF THE MACHINE. — JENNINGS'S IMPROVEMENT. — OBSTACLES TO ITS ORIGINAL INTRODUCTION IN LYONS. — SUPERIORITY OF FRENCH PATTERNS.

THE processes hitherto described are competent only to the manufacture of plain goods; and although, speaking strictly, all that is absolutely necessary to the wants of civilised man, in respect of the art of weaving, is accomplished when fabrics of this description are produced, yet fashion and the love of variety have always, except in the very rudest conditions of society, occasioned the more ornamental and fanciful productions to be viewed with admiration and adopted with eagerness.

The cynic may sneer at the vanity which seeks to adorn the human frame in varieties of colours, combined into forms and patterns of still greater variety. But it would be difficult to show that the powers of invention, and the ingenuity which this vanity has called into existence, have not been beneficially exerted in providing employment for thousands of industrious artisans, in rescuing tens of thousands from the miseries of hopeless indigence, and by exercising, in various ways, the mental faculties of our species.

The growing intelligence of mankind has long since led them to discard all sumptuary laws, as useless, if not hurtful, to communities, whether they are considered morally or politically. The desire of obtaining that which may entitle us, in the opinion of our associates, to an increased degree of worldly consideration, is a most powerful incentive to the virtues of industry and frugality; qualities which tend most importantly to the general advancement of society, but which are altogether wanting during its ruder stages.

It has been well said by a celebrated philosopher, whose profound investigations have been greatly instrumental in correcting many mistaken notions upon the science of government, which had long been established and held as incontrovertible axioms, that "the natural effort of every individual to better his own condition, when suffered to exert itself with freedom and sincerity, is so powerful a principle, that it is alone, and without any assistance, not only capable of carrying on the society to wealth and prosperity, but of surmounting a hundred impertinent obstructions with which the folly of human laws too often encumbers its operations; though the effect of these obstructions is always, more or less, either to encroach upon its freedom, or to diminish its security." *

It would prove a curious subject of enquiry, to follow out, to their ultimate consequences, and through all their ramifications, the effects resulting to society from the introduction of new luxuries. To ascertain the degree wherein the indulgence, by the wealthy, of wants called into existence by the very means afforded for their gratification, brings other enjoyments within the reach of a larger number, by reason of the new demand for industrious labour thus created; and to learn how a still larger class are, through the spirit of emulation, rendered so desirous of acquiring an equal participation in comforts enjoyed by their former equals, as to give an effectual spur to their industry and ingenuity. Luxuries, when they have been long enjoyed, become, in a manner, necessary to our happiness; to be without them, while others are not so deprived, is to feel ourselves lowered in the scale of society, a degradation to which but few in-

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* Enquiry into the Nature and Causes of the Wealth of Nations, by Adam Smith, vol. ii. p. 365.

dividuals would willingly submit, while the means of avoiding it continue within their reach.

To imagine that communities, after once acquiring a relish for luxuries, can ever fall back to the primitive usages of society, is to conceive what never has occurred, and what, while the human mind remains constituted as it ever has been, never will be experienced. The natural wishes of every man are placed upon the acquirement of something more and better than that which he at present enjoys; and society is thus led, by the concurring efforts of each of its individual members, progressively and steadily onward. Legislative or governmental interference may, indeed, retard the march of improvement, but can no more stop its course when it is once in action than it can stay the motion of the planets.

Figure-weaving is the art of producing various patterns in the cloth, either by the introduction of threads of various colours, or by a different arrangement of the threads, or by using, in the same fabric, threads of different substances.

This interesting art is of very ancient invention, and appears to have been practised by the Egyptians at a very early period. Herodotus* speaks of a curious breast-plate or cuirass, covered with linen, which was sent by king Amasis to the Lacedemonians, and which was highly ornamented with numerous figures of animals woven into its texture. The historian adds, that each of its apparently slender threads was actually composed of three hundred filaments, which, under a careful examination, were all distinctly visible.

The improvements recently introduced into this ornamental branch of the art have been many and important; but previous to giving any description of these improvements, it may be as well to explain, generally, the more simple, although more laborious and less perfect, means, whereby the weaver was formerly enabled to produce the requisite varieties of form and colour from his loom.

Stripes which occur throughout the length of the piece are the effect of using threads of different colours, or substances in the warp alone, and do not entail any additional labour upon the weaver. Stripes which run across the piece, or in the direction of the shoot, are caused by using different shuttles, furnished with threads of the requisite colours and substances for the formation of the shoot. The only additional labour thus occasioned to the weaver is that of changing his shuttle at certain intervals. A combination of these two methods will, it must be evident, produce a checkered pattern, and thus a very great variety of rectilinear patterns may be obtained.

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* Lib. iii. c. 47.

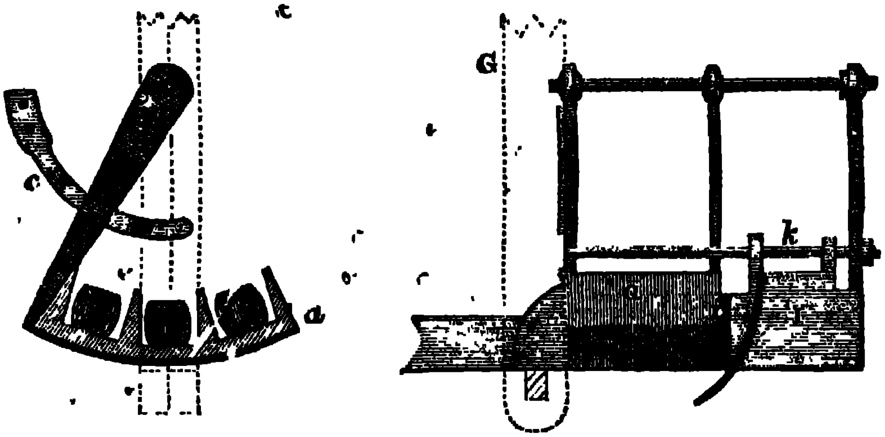
To call forth figures, flowers, or patterns of any other kind, different means are necessary. By dividing the warp between several leaves of heddles, which can be depressed at pleasure by separate treadles, threads of different colours may be either concealed or brought forward upon the face of the goods, at the pleasure of the weaver. These threads may be made to change places one with the other, so as to reveal or conceal each in such a way as to make out the particular pattern intended.

Where threads of different colours or substances are employed in forming the shoot, the shuttles containing such different threads must be substituted as often as is required by the contemplated change of pattern. To effect this substitution with but little trouble or loss of time to the weaver, a very simple but effectual contrivance is used.

One of the troughs connected with the shuttle-race must be made in two parts, thus: —

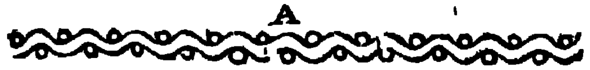
The box, here shown, forming part of the trough in which the shuttle is placed between the warp and the pecker or driver, can be easily exchanged for another box, furnished with a different shuttle, having wound in it a thread of the kind wanted. In order to facilitate this exchange of the shuttles, the movable part of the trough is suspended from a centre of motion, as at *b*; by swinging, therefore, the box *a* on its centre, any one of its divisions may be brought opposite to the driver, so as exactly to coincide with it, and to form part of the same trough in continuation of the shuttle-race. The upright bar of the shuttle-box *a* works, as is seen, upon a curved arm *c*, which is furnished with pegs or catches to confine the bar in the precise position which it should occupy. If more than three different coloured threads are wanted to form the shoot, there may then be two movable boxes for the shuttles; one being placed at each end of the shuttle-race.

Fig. 18.



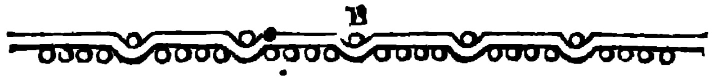
Tweeled or twilled cloth is a description of figure weaving depending upon peculiar arrangements of the threads that compose the warp and shoot. These arrangements may be almost infinitely varied and complicated, so that it would be difficult to convey a clear or adequate description of every variety; nor, indeed, would it be useful in a work like this to do so. It is, however, easy to communicate an idea of the principle that enters into and governs this method of weaving, which will be at once understood by consulting the two following diagrams.

Fig. 19.



A represents in section, but greatly magnified for the purpose of clearness, a piece of cloth woven in the simplest manner. The circles are intended to represent the section of the warp, and the waved line which passes alternately above and below each following thread of the warp is the weft or shoot: this on its return is, by the altered position of the threads of the warp, made to pass beneath those threads which it had before passed over, and over those under which it had been previously directed.

Fig. 20.



B represents, also in section, a piece of twilled cloth, where the waved line or shoot is seen to pass over four threads, and under one thread of the warp; while it is manifest that by the alternation of the heddles the shoot, with the return stroke of the shuttle, will pass under four threads and over one thread of the warp. It must not be understood, that in weaving twilled fabrics the shoot invariably passes under or over four threads before interlacing with the warp, or that it then interlaces with only one thread; the number of threads so passed over may be two, three, four, five, or more, in fact, any number greater than one, although seldom fewer than three; and the interlacing may be with two or more threads, according to the pattern which it is desired to produce, and which of course will vary according as the number of threads passed over or interlaced is greater or less. All the intersecting points where the threads of the warp and shoot cross or interweave are more marked to the eye from the circumstance of both threads being seen together. These points take the form of diagonal lines, extending parallel to each other, across the face of the cloth, and the degree of obliquity will vary according to the number of warp threads passed over without interlacing with the shoot. In twills of the coarsest fabric the shoot is interwoven with every third thread of the warp; and in proportion as the materials wrought are finer, longer intervals are allowed, until, in some of the finest silks, the interlacing takes place with only each sixteenth thread.

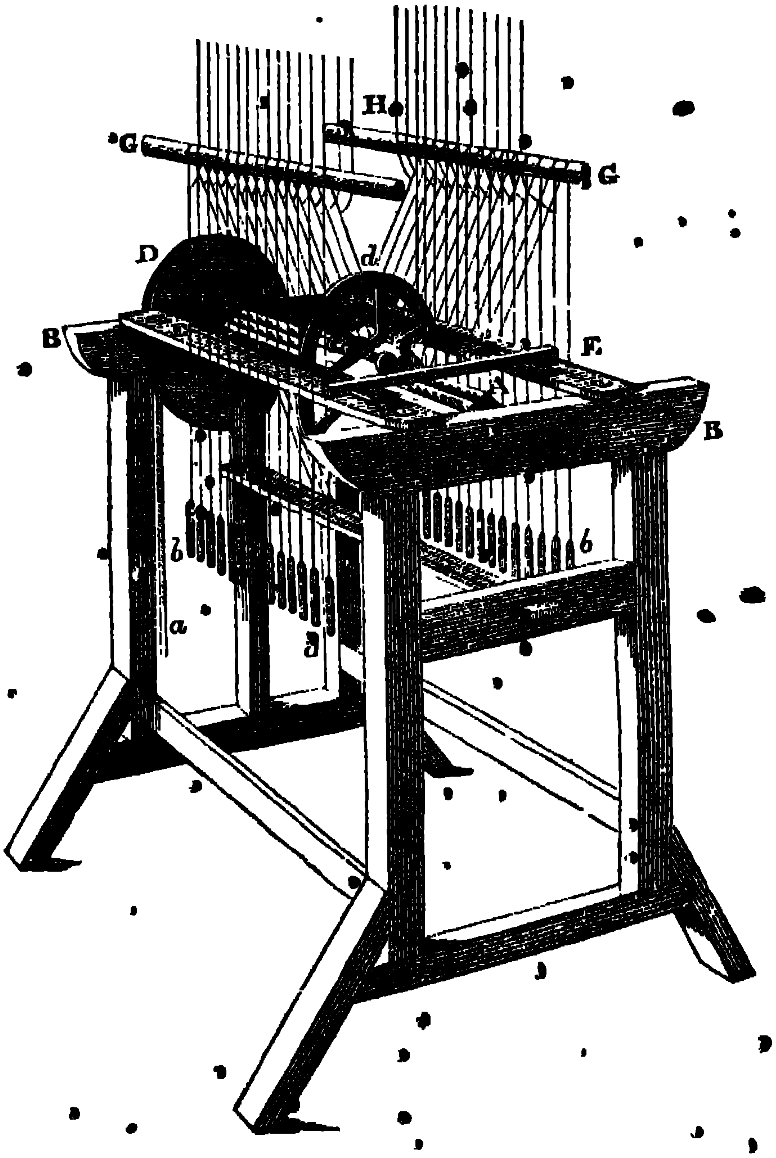
All the varieties of twilling depend upon the mounting or working of the different leaves of heddles, or the harness of the loom: these, by their multiplication and by their connection with a greater number of treadles, which can be made to work in different orders of succession, vary the arrangements for separating the threads of the warp in forming the shed, thus, according to the weaver's phrase, augmenting the number of *leases* in the harness.

In forming patterns where the variety is extensive, the number of treadles that would be necessary to accomplish this mode of weaving would be so great, that one man could not possibly manage them with his two feet. By placing one of these inadvertently upon a wrong treadle, the uniformity of the work would be interrupted, and the pattern disfigured; and it could not be expected that, while urging forward his work with the celerity necessary for the adequate support of his family, any man could so bestow his attention upon every part of his operations as to ensure the absence of all errors of this description.

The regularity and precision which are necessary in producing fanciful patterns of great variety require, therefore, a different description of loom. To meet this necessity, the apparatus called a draw-loom was invented: by means of this the most comprehensive patterns were produced; and in using it the weaver was absolved from all extra attention, having only to apply his feet, as in the commonest kind of weaving, to two treadles alternately. The working of a draw-loom formerly required the constant attention of two persons, one of whom was employed to raise the heddles in their requisite order of succession, by pulling strings attached to the various leaves respectively, while the other carried forward the operation of actual weaving; but during the year 1807 a most valuable invention was brought into use and substituted for the second person employed. The saving of labour resulting from the use of this apparatus comprised, perhaps, the least part of its advantages, since it removed, by the unerring certainty of its operation, all possible chance of mistake in pulling a wrong string, which, while the office was performed by human hands, could not but sometimes occur. The apparatus, when once properly set up, itself provided for all the operations and changes required.

This machine, which, from its standing in the stead of a person who was distinguished by that name, is called a draw-boy, will be now described; and this will supersede the necessity for giving any more particular explan-

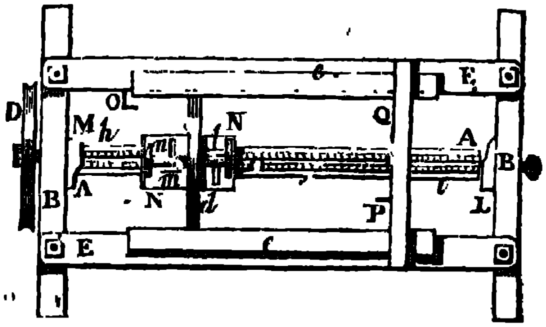
Fig. 21.



ation of the draw-loom as it existed prior to this most material improvement.

Fig. 21. is a perspective view; *fig.* 22. a plan of the machine; *figs.* 23. and 24. are parts of the apparatus, which may be referred to for clearer elucidation. The same letters, when they occur in the different figures, apply to the same parts.

Fig. 22.



The machine was fixed at the side of the loom in the place where the assistant weaver used formerly to stand. A A is a square axis made of wood, and so mounted as to turn backwards and forwards in the frame B B on

Fig. 23.

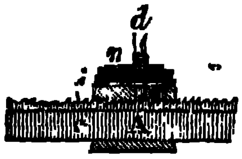
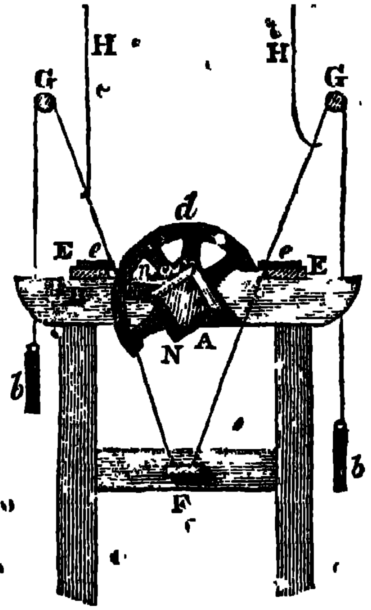


Fig. 24.



centres of motion. The pulley D is fixed at one end of the frame, having a line *a a* fastened to it at its highest point. The axis is put in motion by means of this line, each end of which is connected with one of the treadles of the loom. E E are wooden rails or shelves fixed across the frame parallel to A, and *e e* are brass plates screwed to these shelves, and pierced with a great number of holes to receive as many cords, for a purpose that will appear. F is a central rail placed beneath the reciprocating axis A A, and to this rail are fastened cords, which, passing through the perforations of the plates *e e*, are turned over rounded rods G G, and kept extended by the weights *b b*: the rods G G are suspended by cords at each end from the ceiling of the room. To each of the cords which passes from F through the plates *e e*, and just before they are turned over the rods G G, another cord is attached. The latter cords are represented by H, and hang loosely, their upper ends being connected with lines extending horizontally across the ceiling of the room, to which they are fastened by one end, while the other end of each passes over a pulley placed at the top of the loom; and the leaves of heddles or harness are all suspended by lines thus conducted.

It will now be seen, that when any one of the cords fastened to the central rail F is pulled down, it must draw one of the cords H, and act upon that part of the harness which is connected with it: one of the weights *b* keeps the cord at its proper degree of tension. It may be easily understood, that the harness being arranged in such succession as is required to raise and depress the leaves of heddles in a manner which will produce those various situations of the warp which are necessary to the production of the required pattern, it only remains to provide for the regular and successive drawing of the cords as they are mounted in the draw-boy. This is the business of the machine, and is accomplished in the following manner: —

The axis A A has fixed to it a semicircle *d*, grooved in its periphery like a pulley, and with both its ends divided so as to form a cleft hook or claw. Each of the strings made fast to the rail F has a large knot made in it, a little below the point where it passes through and when the axis A is made to vibrate to and fro by the action of the treadles, as before mentioned, one of the hooks of the semicircle *d* seizes upon one of these knots, and drawing down the cord, raises the heddles connected with it.

It must be remembered, that by the connections made between the various leaves of heddles the raising of any one of the leaves must occasion the depression of all the others.

The shuttle being then thrown, the other treadle is in its turn depressed: the axis A, with the semicircle *d*, in its return back, allows the cord to disengage itself from the cleft hook, and to take its original position; the semicircle then inclining over to the other side, its other cleft hook lays hold of the knot made in the cord next in advance of the one opposite to that just released; draws it down; the shuttle is again thrown; and so on in regular succession, each claw in its turn seizing upon the cord next beyond the one directly opposite to that just drawn. The means whereby it is provided that the claws shall take in succession only the alternate cords passing through *e e* are these: — The two racks *h* and *i*, in the plan, *fig.* 22., which are let into grooves in the axis A, have teeth like saws, but the teeth on one rack are inclined in a contrary direction to those of the other. These racks are caused to move backward and forward in their grooves to the extent of one tooth at each vibratory movement of the axis, by the action of two circular inclined planes of iron fastened to the frame at L and M, against which the ends of the racks are thrown by means of spiral springs concealed beneath each rack. The semicircle is fixed on a box or carriage N, which slides upon the axis A, and has two clicks upon it; one at *l*, which falls into the teeth of the rack *h*, the other at *m*, for the teeth of the rack *i*: *n* is a roller, fixed over the box, and connected with the two clicks *l* and *m*, by threads wound in opposite directions, so that one click is always raised up and disengaged while the other is in action. O is a piece of wire fixed to the frame in such a manner as to intercept another small wire projecting from the roller when the axis is inclined, and to turn the roller a short distance: P is another wire, intended for the same purpose, fixed to the movable cross bar Q, which can be fastened as required at either a greater or lesser distance from the end of the axis. If the roller *n* be in such a position that the click *m* is down while *l* is drawn up, the action of the apparatus will be this:—the semicircle first inclines to the direction shown in *fig.* 21., and its hook draws down one string; during this motion, the end of the rack *i* comes to the inclined part of the circular inclined plane M, and is moved by its spring towards D the space of one tooth, which advance is maintained by the click in falling into the tooth. On its return the axis thrusts back the rack *i*, together with the sliding box and semicircle, towards L, causing the claw to catch the next opposite string; and in this manner the semicircle proceeds, advancing one string with each vibration, until it reaches the end of its course. The tail of the roller *n* then strikes against the pin P, the roller is turned over, the click *m* is raised, and the other click *l* is brought into action upon the rack *h*. By this means the semicircle is moved back one tooth for each vibration towards M, until the wire projecting from the roller *n* meets the wire O, by means of which it is upset, the click *m* again comes into play, and the semicircle is by these means kept constantly advancing and receding with the most perfect regularity.

The machine which has just been described was not in all respects the same as the first mechanical draw-boy that was employed, upon which it formed a considerable improvement, by rendering it unnecessary for the weaver to quit his labour at the loom and reset it, whenever the semicircle had completed its progression from one end of the frame to the other. This improvement was the contrivance of a Mr. Duff; it exhibits great ingenuity, and the apparatus proved eminently useful, although liable to one very serious objection. The weight of the harness and the friction of the machine being considerable, it was necessary to adjust accordingly the range of the treadles which gave it motion; and in order not to oppress the weaver with the weight, it was requisite that he should depress each treadle to the extent of ten inches. The exertion of raising his feet so high, and in such quick succession as was needed, proved exceedingly fatiguing, and even affected injuriously the bodily health of the weaver. To remedy this evil, an engine maker, named Jones, fixed on the axis of the driving wheel or pulley D two cranks, each being about two thirds of the length of the radius of the wheel. But it was found, as indeed might have been expected, that this arrangement increased the load and friction so disproportionately to the advantage that was gained by shortening the tread, as to render it hardly available in practice. It was, perhaps, a rather better contrivance when a weaver, named Hughes, substituted for the above mentioned cranks a small grooved wheel, which he fixed on the axis of the driving wheel, and connected it with the treadles by means of cords passing over pulleys; but the evil, although diminished by this means, was not removed. In the years 1820 and 1821, another ingenious silk weaver, named Rickards, made a farther and effectual improvement, by attaching to the prolonged axis of the machine an arm, carrying a leaden weight of such magnitude as would counterbalance the weight of the harness.

The apparatus, thus improved, continued for a long time to prove of great usefulness in figure weaving. It detracts nothing from the merit of the inventor and improvers of a machine which removed so many of the disadvantages attendant upon the system of figure weaving, as then usually practised, that another and a better system has since been imported from a neighbouring country, which has occasioned the laying aside of the draw-loom and its attendant draw-boy, for the production of figured silk goods.

The contrivance whereby this new system has been accomplished is the invention of M. Jacquard, who was a practical weaver of Lyons. Bearing his name, it will probably prove a lasting record of his mechanical talent, and will secure for his memory that fair harvest of fame, which, unhappily, he has not lived to reap, having fallen an early victim to the intensity of his mental application.

In the course of the very few years which have elapsed since its first introduction into this country, the Jacquard loom has entirely taken the place of every other method of figured silk weaving, and has been, in no small degree, instrumental in bringing that curious and beautiful art to its present state of advancement. The elaborate specimens of brocade, which used to be brought forward as evidence of skilfulness on the part of the Spitalfields weavers of former days were produced by only the most skilful among the craft, who bestowed upon their performances the most painful amount of labour. The most beautiful products of the loom in the present day are, however, accomplished by men possessing only the ordinary rate of skill, while the labour attendant upon the actual weaving is but little more than that demanded for making the plainest goods. The carefulness and skill now required in preparing the various arrangements of the harness in the loom, or, to use the technical phrase, in *building the monture*, are out of all proportion less than were called for before the introduction of Monsieur Jacquard's invention, the principle and operation of which will appear from the following drawings and description.*

The apparatus is fixed on the top of the loom, in a perpendicular line with its harness, which is attached to the lifting hooks *a a*. These hooks are passed perpendicularly through eyes in an equal number of horizontal needles *b c*, which lie in rows in the frame *d d*. Of these lifting hooks and needles, only eight are shown in the drawings, in order to simplify the description; whereas, in the actual machine, there are as many as 400 of each, or fifty in each one of the eight rows, forming as many leases or lashes in the warp. The horizontal needles *b c* protrude through the frame *d d* at *c*, and are kept in that position by helical or spiral springs *e e*, placed in cavities

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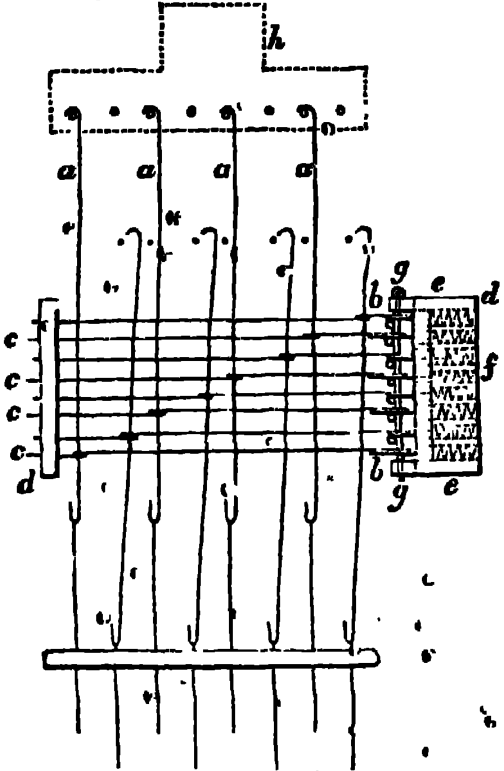
* The drawings inserted for the elucidation of the Jacquard machine are merely outlines; a mode of delineation which is necessary, in order to render apparent its internal construction and action, which are concealed in the actual machine by the framing wherein the apparatus is contained.

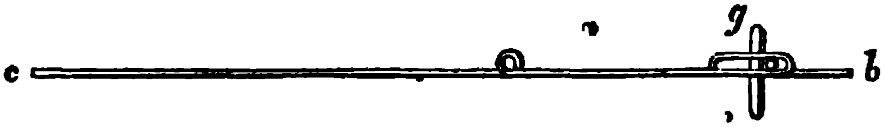
Fig. 25.



in the frame *d*, and there confined by vertical wires *f*, so that any degree of pressure being applied against the points of those needles at *c* will cause them to retire into the frame *d d*, and, on the removal of this pressure, the elasticity of the springs will again drive the needles forward. The range allowed for this horizontal movement of the needles is limited by vertical pins *g*, passing through loops made in the needles, and which stop them at a certain point. Close to these vertical pins, others are placed horizontally, upon which the loops of the needles slide, and by means of which they are retained in their proper position. One of the needles is shown separately, for clearer elucidation.

Above the frame *d d* is another frame *h*, having bars ranged horizontally at right angles with the needles, and in number equal to the rows of lifting hooks. This frame *h* is alternately raised from or lowered upon the frame *d d*, by a lever attached to and acting with the treadle, and the length of the lifting hooks is so adjusted, that when the frame *h* is lowered the lifting bars would so insinuate themselves under the curved ends of the lifting hooks as to raise them when the frame *h* is again raised. For this purpose, the lifting bars, which in shape are something like blunted knife blades, have their broad parts a little inclined out of the perpendicular, so that their lower edges shall not strike in their descent against the curved extremities of the lifting hooks, while, by their continued depression, the flat parts of the bars will come in contact with those curves, and force the hooks somewhat back against the springs. These, at the moment they are freed from the pressure by the descent of the bars below the curves, force the hooks back into the vertical position, which ensures their being suspended on the lifting bars with the upward movement of the frame *h*.

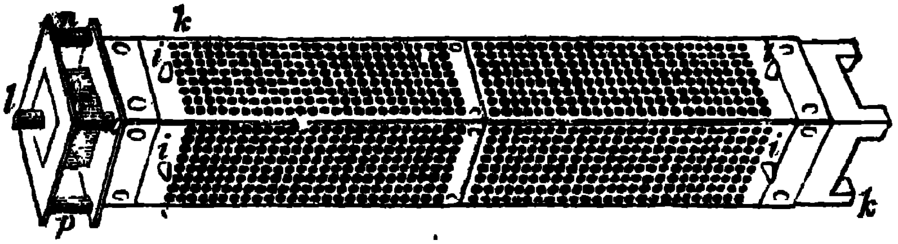
Fig. 26.



It will be observed that half the number of lifting hooks are attached to the lifting bars, while the other half remain disconnected with them: this has been effected by the forcing back of the needles, through the eyes of which those lifting hooks are passed, and which, by that act, are thrown out of their perpendicular, and are thus carried out of the range of the lifting hooks. All, therefore, that is further wanting to govern the raising and depressing of the different portions of the warp is a system for managing the retirement of the proper needles within the frame *d d*, and, consequently, for influencing the taking up of the proper heddles by means of the horizontal lifting bars.

This system of management is effected by the agency of a square revolving bar, and a succession of perforated cards or slips, which are carried round with its revolutions.

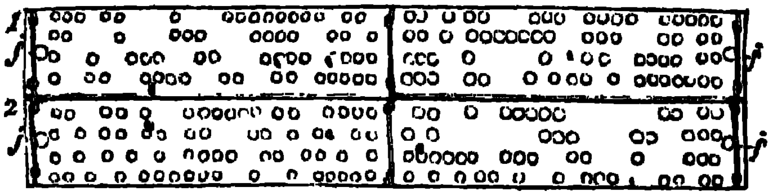
Fig. 27.



The revolving bar is perforated on each of its four sides, with holes, answering, in number and position, to the points of the needles at *c*; and one or other of these sides is brought into contact with that same part of the frame *d*, at each depression of the treadle.

In the absence of the cards or slips, the points of all the horizontal needles *b c* would enter into the perforations of the revolving bar, and every one of the lifting hooks would be taken up on the lifting bars; whence the office of the cards becomes apparent. These are partially perforated, in such a manner as to make out the intended pattern by means of the partial influence they are made to exert in causing the retirement of the horizontal needles. It will be seen, by reference to the cards or slips, that their perforations are not so numerous as those on the sides of the revolving bar, and that these holes occur at irregular positions. If, then, one of these slips of card be made to cover the side of the revolving bar which is opposed to the points of the needles, such of the latter as do not coincide with the perforations made on the slip will be driven back against their helical springs. Their lifting hooks will, consequently, be carried beyond the range of the lifting bars; while all those needles which find coinciding perforations in the card slip will

Fig. 28.



pass through it into the perforations of the revolving bar; their lifting hooks will, on the depression of the frame *h*, be engaged by the lifting bars; and those portions of the harness which are connected with them will be drawn up.

The perforations in the slips are so placed as to occasion that succession in the raising of the harness which will make out the intended pattern. For this purpose it is necessary to have as many cards or slips as there are required threads of shoot to make out or complete the pattern; this number of cards, where the pattern is large, or of great variety, is very considerable. The whole of them are fastened together by threads at their extreme ends or corners, in the manner shown in the drawing; and they thus form a kind of endless chain, one complete revolution of which makes out the pattern, which the continued working of the loom repeats to the end of the warp.

The revolutions of the card slips with the revolving bar, and the precision with which they must take their position upon it, so as to cause the coincidence of their perforations, is provided for by conical studs *i i* upon the revolving bar, upon which studs the slips adjust themselves by means of the larger perforations *j j* made in them for that purpose.

The punching of these card slips for the composition of different patterns is a distinct and separate business from that of the weaver, to whom the cards are given out, together with the silk to be woven, by the master manufacturer. A sort of property in the pattern is thus retained by the master, which, should it become a favourite with the public, proves to him an affair of some considerable advantage.*

The regular and successive revolutions of the square revolving bar are thus managed.

The bar *k* must be hung by its end pivots *l* in a frame *m*, which is so jointed above as to swing from and to the side of the frame *d* with an unvarying motion. The bar, which has been shown separately, will be seen to have at one end four pillars *n o p* and *q*, into which the hook *r* catches in succession, so as to cause the bar to make one fourth of a revolution. The precision of this

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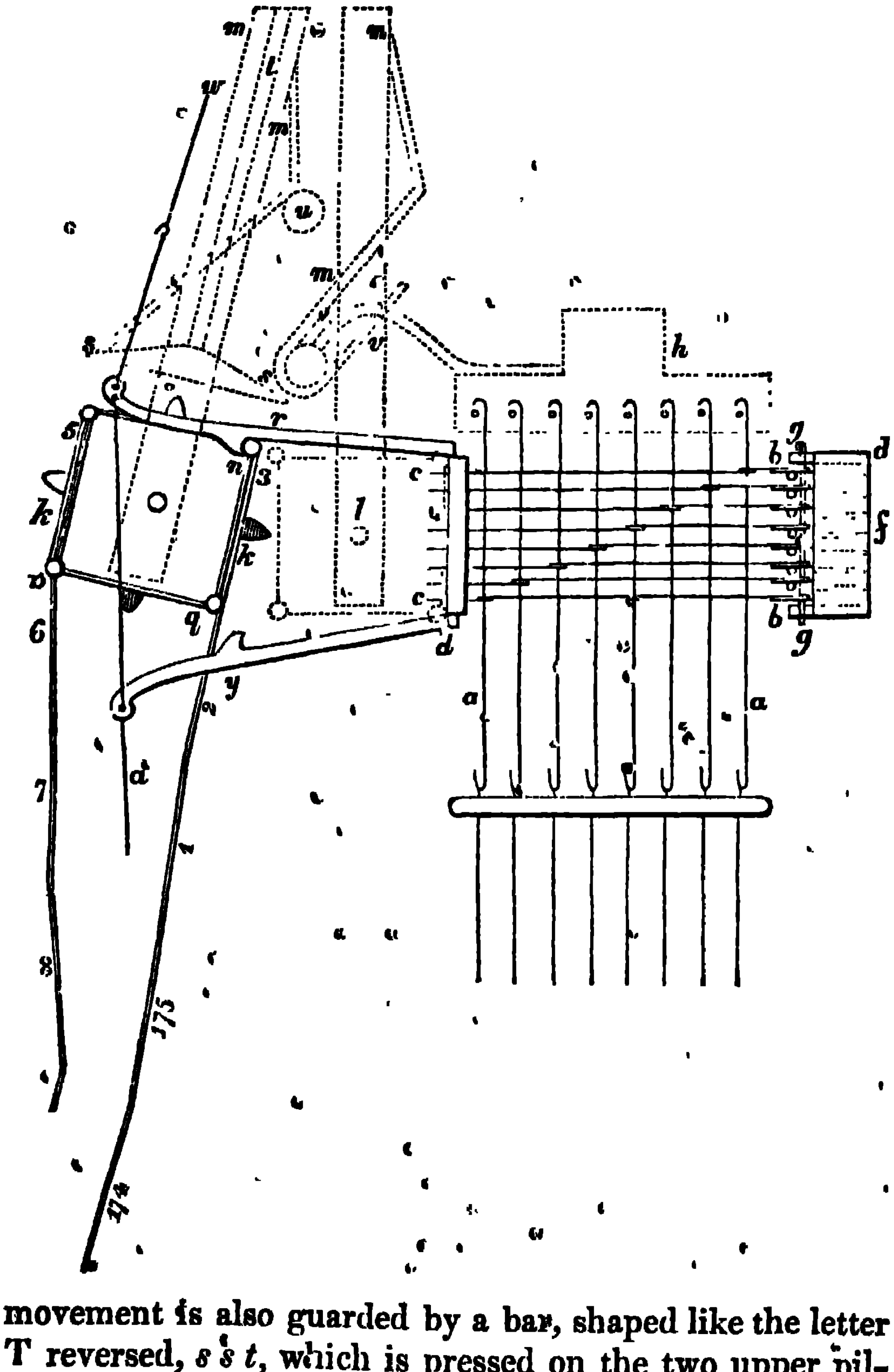
* Note GG.

Fig. 29.



movement is also guarded by a bar, shaped like the letter T reversed, *s s t*, which is pressed on the two upper pillars of the revolving bar by the action of a spring. The frame *m* is swung from the frame *d* by the roller *a*, which, being attached to the frame *h*, rises with it, and works in the hook-shaped bar *v* attached to the frame *m*, causing the latter to swing on its upper joint; and by the same means the depression of the frame *h* must again draw the frame *m* to the position it had quitted against the frame *d*.

The catching of the hook *r* in the pillar *n* permits the swinging of the frame *m* only through the turning of the revolving bar, the outer vertical side of which is thus made to take a horizontal position in the upper part of the frame *m*. By its return against the frame *d*, another of the pillars, *o*, is brought within the hook *r*, and secured in readiness for the next swinging movement of *m*. The revolving bar is thus seen to have both a vibratory and a revolving motion; the first occasioned by the swinging of the frame *m*, to which it is connected on its pivots, and the second by the restraining action of the hook *r*.

The cord *w x* so connects the two opposite and similar hooks *r* and *y*, that the drawing of this cord upward will throw the hook *r* out of action, and cause the successive catching of the pillars *n o p* and *q* by the hook *y* instead, when the motion of the revolving bar will necessarily be reversed. This provision is made in order to enable the weaver to repair any accident that may occur, through the probable breaking of the warp threads, or the possible disarrangement of the harness. The movement of the card slips being of course reversed by this means, the weaver tries back his work sufficiently to accomplish his purpose; and then, by pulling down the cord *w x*, the lower hook is released, and the upper one is again engaged, so that the revolving bar and the card slips once more proceed in the forward direction, and the weaving again advances.

The lines numbered 1, 2, 3, &c. represent the card slips and their situations during the working of the loom. The junction of the slip numbered 175 to that numbered

It shows how, by the repeated succession of all the cards, the endless repetitions of the pattern are produced in the manufacture.

It will be observed, that the card slips are so perforated, that, in addition to the blank spaces necessary to make out the particular pattern required, they likewise oppose blanks, alternately, through their whole extent, to each intermediate row of needles in the frame *d*. If the card No. 1. entirely covers the first, third, fifth, and seventh rows of perforations in the revolving bar, the card No. 2. will, in like manner, cover the second, fourth, sixth, and eighth rows; by which means the requisite succession of the harness is uniformly preserved.

Availing himself of this necessity for covering the alternate rows of perforations, Mr. J. Hughes, of Bethnal Green, has ingeniously proposed to employ the same set of card slips in producing two distinct patterns, by using their intermediate blank spaces, and causing the requisite succession of the harness by means of other cards, perforated accordingly, and which are fixed, with that view, on the different faces of the revolving bar, so that the first and third faces have their first, third, fifth, and seventh perforations covered, while the second and fourth faces have their other four alternate rows concealed: these fixed cards thus become substitutes for the intermediate blank spaces on the revolving card slips, and some part of the expense and labour connected with the second pattern are saved.

The Jacquard loom has proved so beneficial to the weaver, by simplifying the most difficult portion of his labour, and by so importantly economising his time in the preliminary, and, to him, profitless preparation of his loom, that he complains not of the exertion for which it calls in depressing the treadle and lever, although this exertion must needs be very considerable, from the friction of its parts, the resistance of so many springs, and the raising of the numerous weights, by the re-action of which the harness of the loom is depressed. It is some time, however, ere the weaver who adopts the use of this really beautiful apparatus becomes sufficiently familiar with its arrangements to carry forward his labour with a satisfactory degree of celerity; but when this is once accomplished, the comfort which he derives from those arrangements affords ample amends for the cares of his noviciate; and there are not any by whom, under such circumstances, it would willingly be abandoned.

The Jacquard apparatus is provided by the master manufacturer, and continues, of course, equally with the card slips, to be his property; an arrangement rendered necessary by the poverty of the weavers, scarcely one of whom could furnish the means for providing the machine.

Each set of cards, when it is removed from the loom to make room for another set with a different pattern, is carefully tied up, and, as a distinctive label, the bundle has attached to it a portion of the fabric which has been woven, so that the manufacturer may know, at a glance, what set of cards to employ for the production of any one of his particular patterns.

The general introduction of this apparatus was impeded for some time, owing to the great height which was required in the apartment destined for its erection. Within the last twelve months, an improvement has been effected, which renders the invention more extensively available, by admitting of its erection in apartments not beyond the ordinary height of chambers inhabited by silk weavers. This improvement was brought under the notice of the Society for the Encouragement of Arts, Manufactures, and Commerce, and was, on that occasion, deemed deserving of reward both pecuniary and honorary. This society has always been alive to the great importance of the silk manufacture to this country, and has done more for the encouragement of ingenious artisans in this branch of industry than has been, or than could be, effected by the patent laws under the present system; the great bulk of the inventors being in a situation of life which deprives them of all means for securing to themselves the privileges of a patent.

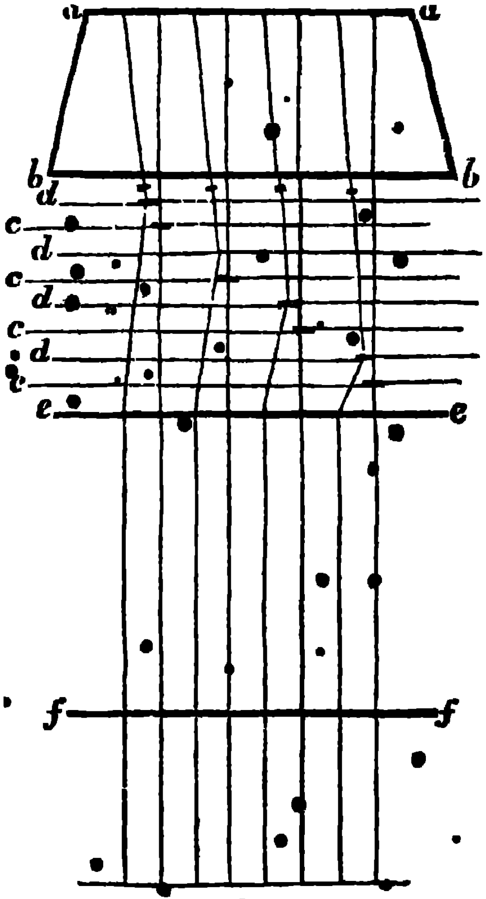
To give an intelligible account of the alteration thus effected, it is necessary to explain, that the cords whereby the leaden weights, which are called lingos, are attached to the harness, are each led through a hole in a board in front of and somewhat lower than the breast-roll of the loom: this is called a comber-board; and its numerous holes are so disposed in lines, that the rows which cross the loom comprise a greater number of holes than the rows which run in the direction of its length. On the other hand, the rows of lifting hooks contained in the apparatus above are in the greatest number in this last-mentioned direction. In attaching the harness to the lifting hooks, it had been usual to connect each cord with that individual hook which would have stood in the most natural relation to it, provided the comber-board and lifting hooks had stood in the same direction; but as they do not so stand, it is evident that this disposition of the cords must occasion a twisting of them among each other; and hence arose the necessity for carrying them through a wider range of space, that the chances of entanglement or confusion might be diminished. This mode of connecting the harness with the lifting hooks is called "the London tie." The improvement consists in connecting each cord with the individual hook which stands in the most natural relation to it in the actual position of the different parts: this is called "the Norwich tie;" and by reason of its diminishing the chances of entanglement among the numerous cords, makes it practicable to confine the harness within a narrower range of space.

Besides the economy of space thus acquired, it was found practicable to diminish, in some degree, the height given to the framing of the apparatus; and the combination of these two circumstances brought the whole machine, as has been before mentioned, within the height of chambers such as are commonly inhabited by journeymen weavers. Previously to this alteration, it had been by no means uncommon to cut away the ceiling of the apartment in the spot directly over the Jacquard apparatus, but it is obvious that recourse could not always be had to even this bungling expedient.

The Society for the Encouragement of Arts has very recently given encouragement to another alteration, which effects a very desirable simplification of this ingenious invention, dispensing altogether with the helical springs which serve to push forward the needles, and substituting cords and perforated boards for the lifting hooks and lifting bars of the original machine.

This improvement is the contrivance of Mr. William Jennings, a practical weaver and machine-maker, of Bethnal Green. The means whereby it is attained will appear on consulting the following diagram:—

Fig. 30.

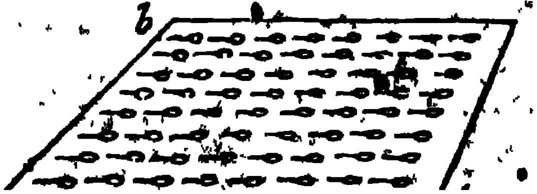


The cords attached to the harness, of which, to avoid confusion, eight only are here given, are fastened to the top of the frame *a a, b b,* which is to be raised by the action of the treadle and lever. The under board *b b* of this frame, through which the cords pass in their descent, is perforated with the requisite number of holes; and in connection with each one of these holes is a small slit, the width of which is narrower than the diameter of the hole from which it proceeds. This perforated board *b b* answers the same purpose as the lifting bars; for each of the harness cords having a knot made in it in the exact spot to which the lower board *b b* of the frame will descend with the return stroke of the lever, either these knots will, by the protruding of the needles as at *c c*, be detained upon the upper surface of *b b* from their inability to pass through the slits, or, by the passing back of the needles, as at *d d*, the knots will be made to coincide with the holes in *b b*, through which they are small enough to pass freely. The portion of the harness with which they are connected will, consequently, not be raised. Another perforated board, *e e*, is placed beneath the horizontal needles, and through this the cords descend to the comber-board *f f*, which is similar to the one formerly described: the cords of the harness, passing through this, are kept extended by the plummets, or lingos, at their bottom ends; and these perform the office of springs in bringing forward the horizontal needles *c c*, *d d*, whenever they meet with coinciding perforations in the revolving bar; the lifting cords then insinuate themselves between the slits, and are raised by means of their knots, as before described.

For clearer elucidation, the board *b b* is here given, with its circular holes and slits for the passage or detention of the knots. It must be borne in mind, that instead of the small number here delineated, this board has 400, and sometimes even a greater number, of holes and slits, but the indication of which in so small a space as this diagram would have rendered it less clear and intelligible.

In the course of the very few years during which the Jacquard machine has been known in England, it has been thus materially simplified and improved; while in Lyons, the city of its birth, it still remains unaltered, either in form or arrangement, from the original conception of its first ingenious inventor. It has been recorded by the baron Ch. Dupin, that Jacquard had to encounter the most bitter annoyances from his fellow-citizens, who have been so materially benefited by his ingenuity. Several years elapsed before his machinery was generally adopted, during which period a thousand obstacles were offered to its introduction; a fact which can well be credited by all persons who have had opportunities for observing with what pertinacity old forms and practices are adhered to by the common-place bulk of every community; and how great is the disinclination of the operative mechanic to adopt improvements which, with a self-sufficiency engendered by the dexterity acquired in following old methods, he is pleased to condemn as "new-fangled nonsense."

Fig. 31.

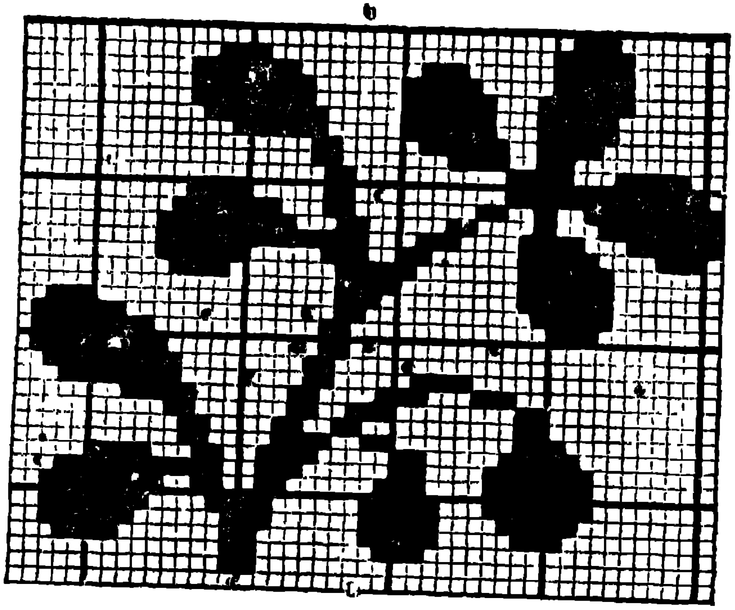


The mode whereby the perforations in the card-slips are so made as to influence the raising of different portions of the warp threads in the order of succession necessary for making out the desired pattern, is exceedingly ingenious.

The pattern—or, as it is called, the design—is drawn of a size much larger than it is intended shall be given to it in the woven fabric, upon paper previously divided by lines into very small squares, in the manner described in the following figure, the cross lines of which represent the intersecting threads of the goods. This mode of proceeding has long been followed in *building the monture* of draw-looms; that is, in preparing them for weaving intricate or extensive patterns.

Placing this paper before him, and provided with a frame containing a number of vertical threads answering to the warp of the goods, sufficient to comprise the width of the design, the workman proceeds to *read on* the design,

Fig. 32.



by taking up with a very long needle such of the threads as are intersected by the pattern, inserting by its means a cross thread under these, and carrying it over all the remaining threads in the same line; repeating this process until he has inserted as great a number of shoots as there are of cross lines occupied in making out the pattern, and which sometimes amount to as many as five hundred shoots. Thus, in fact, transferring the design by a succession of what may be called darning stitches from the ruled paper to the threads in his frame.

To facilitate the reading on of the design, every tenth line which divides the pattern paper into squares is described in a bolder manner than the other lines. When the design is extensive, the operation is generally performed by two persons, one of whom directs what threads are to be raised, while the other makes the necessary insertions of the needle. In reading on the design here given (*fig.* 32.), the beginning would be made at the bottom, and as the spaces on the paper are always counted from right to left, the instruction would be, "pass thirty and take two." Part of the flower is described in the second row of squares, and the instruction for this would be "pass nineteen, take three; pass eight, take two." The third shoot comprises other parts of the flower, and the workman would be told, "pass ten, take three; pass five, take five; pass seven, take two; pass seven, take four;" and proceeding thus with as many cross shoots as there are of transverse lines on the paper, which in this case comprises only thirty-five, the whole design would be included.

When this is done, the next operation is to attach the threads thus interlaced to the card-punching machine. This piece of mechanism is in every way similar in its principle, and nearly identical in its arrangements, with the Jacquard machine; being, like it, provided with lifting-cords, and wires, and needles, all connected in the manner already described in this chapter, so that by pulling the lifting-cords, the needles will be protruded. In front of these needles, and answering to the revolving bar, a perforated plate, about two inches thick, is fixed: each of the perforations in this is provided with a moveable steel punch or cutter of a cylindrical form, so that the protrusion of any of the needles will drive forward their corresponding punches, and deposit them in another similarly perforated iron plate, about one inch in thickness, temporarily applied for that purpose against the face of the plate first described.

One end of each warp thread in the pattern is then to be connected in succession with the individual lifting cords of the machine; and it is evident that if the different threads which form the shoot, and which for this purpose are made to hang out on each side beyond the selvage of the warp, are taken separately and in succession by each end and drawn upwards, all the warp threads wherewith each cross thread is engaged, will be separated from the rest, and may be collected together in the hand; by then pulling them, the particular lifting cords to which they are attached will be drawn, their corresponding needles will be protruded, and the cylindrical cutters by that means driven out of the perforations in the fixed plate into the corresponding cavities of the moveable plate.

The blank card-slip, which is to be perforated, is next applied to the face of the moveable plate, and against the points of the punches; and both being then removed together, and placed upon a third perforated plate in a press, the punches are driven through the card-slip in the requisite spots. The punches being replaced in the machine, a second shoot of the thread pattern drawn up, and its interlaced warp thread pulled as before, the punches connected with the answering lifting-cords and needles are in like manner protruded into the moveable plate, and forced through another blank card; and, by proceeding in this manner, the whole series of card-slips will be unerringly prepared. Having been previously numbered, there is no difficulty in attaching them together in their proper order of succession, holes for this purpose being made by the same action of the press which stamps the perforations for the pattern, punches for this purpose being permanently inserted in proper cavities of the moveable iron plate.

A modification of the Jacquard machine has been introduced to use by Mr. Samuel Dean, of Bethnal Green, also an operative weaver. In this the card-slips are altogether dispensed with, by adopting the use of two revolving bars placed on opposite sides of the machine. Each of these bars has eight faces, and the loom is actuated by two treadles. The variations of pattern are provided for in the working of this machine, by temporarily stopping such holes in the revolving bars as will influence the raising of those threads of the warp upon which the production of the pattern depends. It is quite obvious, however, that this modification can only be applied to the production of very simple patterns, it being capable of employing no more than sixteen casts of the shuttle for their completion. This altered arrangement is, therefore, of very limited utility, and bears no comparison with the truly valuable invention of Jacquard.

In one branch, and that an essential one, of the interesting art of figure weaving, the manufacturers of Lyons enjoy a superior reputation to us; their designs are more pleasing, more varied, and display a more correct taste than ours can boast. For this superiority there is a very sufficient reason furnished, by the establishment existing in that city of "the School of Arts," which offers valuable means for the study of drawing in all its various branches, and where pattern designers are ably instructed in all the best rules of the art which they cultivate.

The English have been considered inferior to their continental neighbours in the faculty of invention, at least in this particular branch of the fine arts. Without entering into the investigation of this question, which might, perhaps, in any case, be decided more under the influence of national partiality than according to the fact, it must be owned that the French have adopted systematic means for calling forth and improving the talent of tasteful invention; while with us this is left entirely to individual and unassisted efforts. It is, besides, probable that the favour wherewith French patterns are received by the leaders of fashion in this country, tends still further to repress the efforts of English artists, as far as originality is concerned; since it is found more profitable to imitate or to copy patterns, thus recommended to the general adoption, than to venture upon producing others, which would be without this adventitious value.

CHAP. V.

MECHANICAL, OR POWER-WEAVING.

GREAT ADVANTAGES OF MACHINERY IN ABRIDGING LABOUR. — FIRST PROPOSAL FOR A POWER-LOOM. — DR. CARTWRIGHT'S INVENTION. — CAUSES OF ITS LITTLE SUCCESS. — PARLIAMENTARY REWARD. — AUSTIN'S POWER-LOOM. — MODE OF ITS ACTION. — REASONS FOR PREFERRING HAND-WEAVING FOR SILKEN FABRICS. — HAND-POWER-LOOMS. — MR. SADLER'S INVENTION. — DOUBLE AND QUADRUPLE LOOMS. — PROPORTION WHEREIN THEY ARE SAID TO ABRIDGE LABOUR.

The means of substituting mechanical power for the labour of the hands in weaving must be classed among the splendid offerings made by genius at the shrine of utility.

The facility thus given to the production of goods has always excited the apprehensions, and frequently has prompted the hostility, of persons previously employed in their manufacture. Even among other and better informed classes there have not been wanting systematic opponents to the introduction of machinery, who, taking up the broad line of argument maintained by Montesquieu, have asserted that the saving of labour is hurtful to the true interests of communities. That the first introductions of mechanical facilities to labour have been, and must always be, accompanied by hardship to the artisans previously employed in any branch so invaded, is a position which, although frequently much exaggerated, is yet incontrovertibly true; but however much the fact may be deplored, and however strenuously the benevolent man should set himself to devise and to practise means for alleviating the unavoidable evil, there still would be but little wisdom, and, taking a more extended view, but little real philanthropy, in setting bounds to the progress of improvements which are calculated to bring the enjoyments and conveniences of life within the reach of a larger number of individuals. The injury to the deprived artisan is probably but temporary, while the benefit to society is lasting and progressive. The very individuals who suffer from this kind of interference with their own particular line of pursuit, are interested in fostering improvements in regard to every other article of human production. The class of consumers must always be more numerous than that of producers; and it would be difficult in the present day to maintain the proposition, that the lasting interests of the many are to be sacrificed for the temporary advantage of a number comparatively insignificant.

It can scarcely be considered as properly belonging to a treatise on the silk manufacture, to enter historically and at length into the question of the first invention of power-looms; or, to speak more correctly, into a description of the means proposed for their achievement, since the practicability of such an adaptation was imagined, and projects for its accomplishment were published, many years before these were submitted to the test of practice.

As early as the close of the seventeenth century, the drawing and description of a loom for mechanical weaving was presented to the Royal Society of London. Although there is every reason for believing that this circumstance was wholly unknown to the ingenious author of the actual loom first employed in this very interesting object, there does not appear to exist any material difference between this machine and the earlier description. The conception and accomplishment of this important invention, by a gentleman totally unconnected with the pursuit of manufactures, unacquainted even at the time with the commonest processes used in weaving, whose pursuits in life were of a nature wholly foreign to the mechanical arts, and whose attention was drawn to the subject by circumstances purely accidental, is a fact so curious and interesting, that the insertion of the following letter, which the inventor, the Rev. Edmund Cartwright, D.D., afterwards wrote upon the subject to the respectable secretary to the Chamber of Commerce in Glasgow, needs no apology:—

"Happening to be at Matlock in the summer of 1784, I fell in company with some gentlemen of Manchester, when the conversation turned on Arkwright's spinning machinery. One of the company observed, that as soon as Arkwright's patent expired, so many mills would be erected, and so much cotton spun, that hands never could be found to weave it. To this observation I replied, that Arkwright must then set his wits to work to invent a weaving mill. This brought on a conversation on the subject, in which the Manchester gentlemen unanimously agreed that the thing was impracticable; and, in defence of their opinion, they adduced arguments which I certainly was incompetent to answer or even to comprehend, being totally ignorant of the subject, having never at that time seen a person weave. I controverted, however, the impracticability of the thing, by remarking that there had lately been exhibited in London an automaton figure which played at chess. 'Now you will not assert, gentlemen,' said I, 'that it is more difficult to construct a machine that shall weave, than one which shall make all the variety of moves which are required in that complicated game.'

"Some little time afterwards a particular circumstance recalling this conversation to my mind, it struck me that, as in plain weaving, according to the conception I then had of the business, there could be only three movements which were to follow each other in succession, there would be little difficulty in producing and repeating them. Full of these ideas, I immediately employed a carpenter and smith to carry them into effect. As soon as the machine was finished, I got a weaver to put in the warp, which was of such materials as sail-cloth is usually made of: to my great delight a piece of cloth, such as it was, was the produce. As I had never before turned my thoughts to any thing mechanical, either in theory or practice, nor had ever seen a loom at work, or knew any thing of its construction, you will readily suppose that my first loom must have been a most rude piece of machinery. The warp was placed perpendicularly; the reed fell with a force of at least half a hundred weight; and the springs which threw the shuttle were strong enough to have thrown a Congreve rocket; in short, it required the strength of two powerful men to work the machine at a slow rate, and only for a short time. Conceiving, in my great simplicity, that I had accomplished all that was required, I then secured what I thought a most valuable property by a patent, 4th of April, 1785. This being done, I then condescended to see how other people wove; and you will guess my astonishment when I compared their easy modes of operation with mine. Availing myself, however, of what I then saw, I made a loom, in its general principles nearly as they are now made: but it was not till the year 1787 that I completed my invention, when I took out my last weaving patent, August 1. of that year."

The history of this invention is farther curious, as illustrating some of the many difficulties which so frequently attend upon the introduction of new plans, and which call for the exercise of patience the most unwearied, and of energies the most unquenchable, to preserve inventions of even the very highest value from falling into neglect and oblivion. How many such inventions have been so lost to the world, at least for a time, it were vain to enquire; that they have been many will be readily acknowledged, when it is considered how seldom are seen combined in the same person, the faculty of invention, with the more active and, perhaps, more difficult quality of perseverance under repeated difficulties and disappointments. The man of common place endowments will combat steadily and successfully against the tyranny of circumstances, while the aspiring efforts of genius are chained down by the hands of ignorance and prejudice. It were, perhaps, wrong to cast this censure upon society, unqualified by the further remark, that inventors are frequently found too far in advance of the age in which they live. The invention of Dr. Cartwright itself affords evidence of this fact. Power-looms could not have been extensively employed at the period of their inception, when the supply of cotton wool did not amount to one tenth part of the quantity which now passes annually through the hands of our manufacturers. Even had the supply of the raw material been increased proportionally with the means for its conversion, the quantity of fabrics which power-weaving has been found adequate to produce would have far outstripped the then existing wants of mankind.

At the end of three years from its first conception, Dr. Cartwright, having, as we have seen, secured to himself the benefit of his invention by patent, erected a weaving mill at Doncaster, and furnished it with looms wherewith to prosecute the business of weaving. These machines were evidently found to be incomplete and insufficient for the purpose, as the reverend doctor procured grants of three other patents successively for improvements upon his first invention; the last of these patents being dated the 13th of November, 1788, as appears from the report of a committee of the house of commons, to whom the doctor's various patents were produced; and not on the 1st of August in the preceding year, as erroneously stated in the foregoing letter; this last being the date of the third patent granted to Dr. Cartwright for this object.

In the many alterations rendered necessary by these improvements, and in the disbursements indispensably attendant upon the establishment of so important a concern, Dr. Cartwright expended a sum of money equal to between 30,000*l.* and 40,000*l.*! and was compelled to abandon his manufactory.

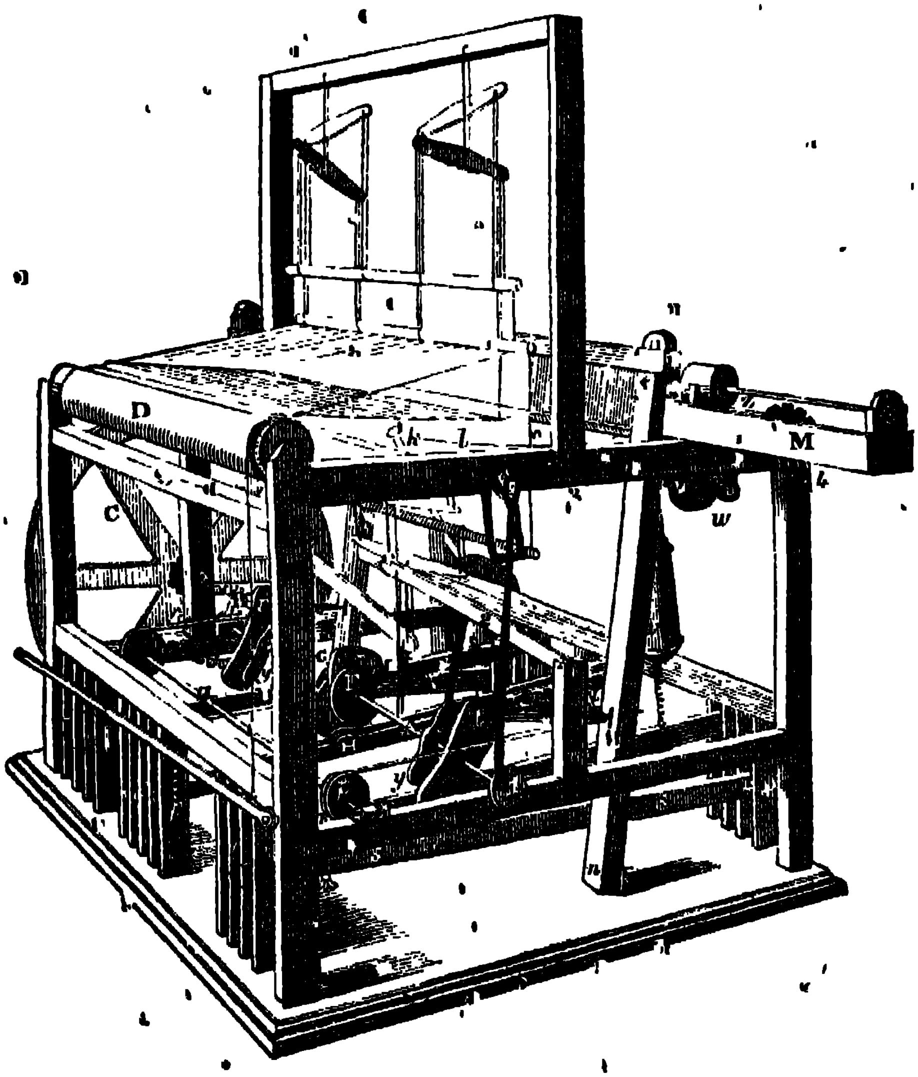
Subsequent to this, in the year 1791, Messrs. Robert Grimshaw and Sons, of Manchester, erected a weaving factory calculated to contain 400 power-looms, and entered into an agreement with Dr. Cartwright for a licence to use his patent. But this establishment was from the first viewed with extreme jealousy on the part of the operative weavers, who feared lest the employment of machinery for effecting the object of their labours should deprive them of the means of subsistence. Threats were held out by anonymous letters, with a view of deterring the parties from proceeding with their factory; and no sooner had Messrs. Grimshaws erected and set to work twelve looms under their agreement, than the building and machinery were wilfully destroyed by fire; and such menaces continued to be used by the weavers as at that time effectually restrained these gentlemen and all other manufacturers from further prosecuting the invention.

Dr. Cartwright's plans accordingly slept until the expiration of his patents destroyed all hope of his deriving any advantage under them. In the year 1808, backed by a recommendatory memorial signed by almost all the principal manufacturers of Manchester and its neighbourhood, he presented a petition to the house of commons, to consider which a committee was appointed; and upon the evidence reported by this committee, the house proceeded to vote to Dr. Cartwright the sum of 10,000*l.* as some compensation for his outlay and disappointment.

In the year 1798, Mr. Monteith, of Pollockshaws, near Glasgow, erected the first power-loom that was applied to the weaving of cotton fabrics. For a long time after this, it was held and believed that the texture of silk, from its extreme delicacy, called for such incessant watchfulness on the part of the weaver, that his eye and hand were constantly required to detect and to remedy defects, which, though trifling and not likely to be observed in the combination of coarser goods, would greatly impair the beauty and lessen the value of silken fabrics. This opinion, although doubtless true to a material extent, has, however, been proved to be not wholly so, since power-looms to a considerable number have been constructed and successfully employed for the production of both broad silks and ribands. It is, therefore, necessary to give some description of the mechanical arrangements whereby, in this as in so many other branches of human industry, the ingenuity of man has subdued even the elements to his power, and has rendered the viewless wind, the impetuous stream, and the raging fire, vassals of his will.

The power-loom erected for Mr. Monteith was constructed by Mr. Austin, of Glasgow, who has placed a model of his machine in the repository of the Society for the Encouragement of Arts, Manufactures, and Commerce in London, from which the drawing herein inserted has been made.

Fig. 23.



A is a square iron axis, which extends through the entire length of the bed of the machine, and when actuated by the cog-wheel B, which is connected by means of a pinion with the fly-wheel C, gives motion to the various parts of the loom; the power being applied to the shaft of the fly-wheel by some one of the well-known methods of communication. D is the yarn or warp-roll. The axis A is provided with several camms, or wheels of eccentric form, which are fixed securely upon it: these, as they revolve, serve,

1. To depress the treadles, and consequently to separate the warp into different portions, as in the ordinary loom is effected by the weaver's foot.

2. To throw the shuttle to and fro through the shed thus created.

3d. To strike the lay or batten against the shoot, and to return it to its proper position: and,

4. To wind the woven cloth upon the cloth-roll as fast as it is formed.

The warp is fixed in this loom precisely in the same manner as has been already detailed in the description of the hand-loom. The same may be said of the mounting of the heddles or harness, and of the provision for insuring that alternating motion whereby the depression of the one causes the raising of the other heddle. The camms on the axis, which take the office of the weaver's feet in working the treadles are both exactly similar in form to each other, but their relative position on the axis is so arranged that they are brought into operation at opposite periods of its revolution. Only one of these treadles can be seen in the position chosen for this representation of the loom, but the exact situation and the mode of working both will be at once apparent, if we imagine the revolution of the axis to carry with it the camm E; this, from its irregular shape, strikes, at the exact period of the revolution that is proper, upon the treadle, and keeps it depressed until a change in the position of the warp is required, when the other camm answering to it is, by the continued rotation of the axis, brought into action, and the treadle first depressed is, at the same moment, freed from the pressure of the camm E; and thus the reciprocating action of the treadles is kept up continually, so long as the axis continues to revolve. Each entire revolution of the axis will, therefore, occasion two separations of the warp by the alternate action of the two treadles.

The second motion, that of throwing the shuttle, is performed by two other camms, F and G, which are likewise reversed to each other in their position on the axis, so as to bring each one into operation at the moment the other is set free. As the shuttle requires to be thrown across the warp with some velocity, and with a sudden or jerking motion, these camms are so shaped as to cause each to strike abruptly upon a lever, and to hold it depressed during a certain portion of the revolution of the axis; quitting it again as suddenly when the corresponding camm is brought to act upon a corresponding lever for the return stroke of the shuttle. When, by the revolution of the camm F, the lever beneath it is depressed, this lever is made to strike with increased velocity upon a shorter lever seen at H, which in its descent carries with it the strap *i*; and this, again, acts upon the segment of a wheel seen to be connected with it. This wheel has fastened to it a long stem of whalebone *k*, which is thus made to snatch the string of the driver *l*, and to impel the latter with the requisite velocity against the shuttle; so that it will be driven out of the trough M, across the shuttle-race, into the opposite trough, pushing back the driver therein to a position proper for the performance of the return stroke. By this time, the rotation of the main axis A has caused the necessary change in the position of the warp threads, the camm G is brought into action, depresses its lever, which again strikes upon a shorter lever answering to H; and this, by acting in a reverse direction upon the segment of the wheel, and consequently upon the whalebone stem *k*, causes this latter to snatch the string of the driver, and by its means drives the shuttle back across the shuttle-race into the trough M.

The third motion, that of striking the lay against the shoot, and returning it to a position proper for again passing the shuttle, is thus performed:—The shuttle-race, reed, whalebone stem *k*, and its segment of a wheel, all form part of the batten frame, which is made to vibrate to and fro on hinges placed at its lower extremities *n*. This frame is drawn backwards by the straps *o o*, which are rolled upon pulleys *p p* fixed upon the axis *q*. Upon this same axis are fixed two other smaller pulleys near to *p p*, upon which other straps *r* are rolled to connect with the long levers *s s*, which are moved during the revolutions of the main axis A by the camms *t t*. These long levers are centred between the short posts of the frame under the shuttle-race. To bring forward the batten and reed, so as to beat up the shoot, two large weights like *v*, one of which is placed at each side of the loom, are suspended by straps from pulleys on a horizontal axis which carries two wheels *w*, one at each side of the loom. On these wheels other straps are wound, which communicate with the frame of the batten, to draw it forward. These weights would not, of themselves, act with sufficient promptness in drawing forward the reed when the loom was working very quickly, and the time required to overcome the momentum which they receive by the backward motion of the batten would derange the regularity of the machine. To overcome, therefore, this momentum, spiral springs are connected between the bottom part of the weights *v* and long levers *x*, which are pressed down at the proper intervals by the camms *y*; these levers being brought into action before the return of the long levers *s s* permits the drawing forward of the batten. The springs are distended; the momentum of the weights is overcome; and they are ready to act instantaneously, by their own gravity, assisted by the energy of the spiral springs. Thus the depression of the long levers *s s* by the camms *t* will draw back the batten from the shoot twice during the entire revolution of the main axis A; and the gravitation of the weights *v*, assisted by the springs, must bring it forward during every interval. The third motion is then completed.

The fourth motion is that of winding the woven cloth, as it is finished, upon the cloth-roll *Z*; which action is thus effected:—At the extreme end of the axis A is fixed a crank, or, as is here shown, an eccentric wheel 1, performing the office of a crank; by the rotations of this, the small rod 2 moves up and down, and turns round a small ratchet wheel to the extent of one tooth during each revolution. The return of this ratchet is prevented by the falling of a click into the teeth. On the axis of the ratchet wheel 3 is an endless screw 4, which, engaging the teeth of a cog-wheel fixed upon the extremity of the cloth-roll, gives to the latter a slow motion, whereby the cloth is wound upon it with due regularity.

The remaining parts of this very ingenious piece of mechanism are so similar both in their form and office to like parts in the hand-loom which have been explained, that particularly to notice them here would be unnecessarily to load a description which will already, perhaps, be thought sufficiently complex.

There have been various modifications of the power-loom, and several contrivances have, at various times, been proposed with the view of rendering it more simple or efficacious. Some of these inventions have been the objects of patents; but, so far at least as principle is concerned, there appears to be no very important variation among them, and it would be of little advantage to enter upon the examination of every trifling difference of construction.

Power-looms which are to be worked by hand, have, on more than one occasion during the last few years, been offered for the adoption of the silk-weaver. In all these machines, the various movements of the treadles, shuttle, and batten, are effected in their regular progressions, by the combination of levers and springs in connection with cranks or wheels.

It is clear that the loom just described, and of which a drawing has been given, is capable of being actuated by manual labour; and it must be equally evident that steam might be employed as the motive force, if it were desired to employ any considerable number of hand-power-looms in the same building. The argument is, therefore, fallacious, whereby it is sought to recommend these later inventions to the prejudices of operative weavers, by representing the looms as being more in accordance with the interests of the workmen. There is, in fact, no difference in the principle upon which both descriptions are constructed and put to action.

Perhaps the most ingenious of these machines which has yet been invented, is one which has lately been made the subject of a patent by Mr. Sadler, of Paddington. It would be improper to describe the mechanical arrangements of this production with minuteness, as all the formalities connected with the specification of the patents are not yet completed. The inventor proposes to construct double or quadruple looms, which, while the working parts of each are complete in themselves, are yet so connected together by a strong cast-iron framing, and working shafts, that the moving parts of each of the two or four looms will be simultaneously and similarly set in motion by the oscillations of a pendulum, which is to be swung to and fro by the hand. In this manner, it is said, on the authority of a weaver who has made the attempt, that without any extra exertion, one yard of silk fabric of a medium quality may be woven in each loom in an hour; so that a workman, during the ordinary duration of his daily labour, may, with one of the double looms, weave twenty-four yards of silk; a result which, if it can be practically realised, would at once relieve the manufacturer from all apprehensions connected with the introduction of French manufactured goods, as it would render the comparative cost of production nearly as much in favour of the English manufacturers as it is now against them. If more than two looms are thus worked in connection together, the weaver would require an assistant in accomplishing his labours.

It is by no means certain that this greater facility of production would prove to the present advantage of the labouring weavers; on the contrary, in proportion as the labour can be simplified, a lower or less instructed class of persons will be employed, for it cannot require the previous preparation of a lengthened apprenticeship to qualify a man for the task of swinging a pendulum. Then, too, the increased quantity of manufactured goods that would be produced by each labourer, would, for a time at least, occasion the employment of a fewer number of weavers; and although the lessened cost of production would, doubtless, induce the consumption of a larger quantity of goods, and thus augment the demand for labour a considerable time would be required for the proper adjustment of this matter, and in the meanwhile the alteration would bear hardly upon the present race of weavers.

Mr. Sadler's loom is a substantial machine, constructed almost wholly of cast iron, and by no means inelegant in its form: it occupies, besides, but a small space. However much it might be calculated to abridge the labour, or add to the earnings of the weavers, still it is to be feared that there are but few among them who could compass its purchase, and thus avail themselves of its benefit.

One cause which weighs materially against the use of power-looms in silk weaving is, that they do not, as is the case in the manufacture of goods from coarser materials, save any great proportion of labour. In weaving linen or cotton fabrics, one man may be competent to afford the needful degree of attention to several power-looms at the same moment; but this is not the case with silk, which, from its delicacy of texture, is continually giving way and requiring repair in some part or other. Then, too, an important amount of time and labour must be expended in removing all roughnesses and inequalities in the warp threads, or, as the weavers call it, in picking the porry, during which the actual weaving must be suspended. The trifling saving in the amount of labour which can thus be realised from the use of any mechanical apparatus, ceases to be an object of much importance, where the value of the raw material forms the principal item of cost in the manufactured articles; and it thence becomes very doubtful whether the use of power-looms, however they may be modified, is susceptible of much extension in any save the commonest branches of the silk manufacture.

CHAP. VI.

VELVET WEAVING.

ITS FIRST INTRODUCTION INTO ENGLAND. — CHINESE VELVETS. — STRUCTURE OF VELVET. — PROCESS OF WEAVING IT. — IMPROVEMENT THEREIN. — FIGURED VELVET. — GERMAN VELVET.

Velvet must be classed among the richest of silken fabrics. Although, compared with the date when the more simple silken structures were first known, this elegant manufacture must be considered as of modern invention, it has, nevertheless, been made and used in Europe for several centuries. Its production was, for a long time, confined to Italy, where, particularly in Florence, Milan, Venice, Lucca, and Genoa, it was carried on to a great extent, and with a considerable degree of perfection. When, however, the French manufacturers took up this branch of silk weaving, they speedily excelled their instructors; and it was from the refugees of that nation, when forced to abjure their country by the revocation of the edict of Nantes in the year 1685, that the art of weaving velvet became known, and was domesticated in Spitalfields, where it has since continued, and has been followed with success.

The same cause having driven another portion of the French protestants to Holland, occasioned equally in that country the knowledge and prosecution of this process. At Haerlem, especially, a very considerable establishment was made with this object; but its productions were never brought successfully to rival the beauty of French velvets, which continued for a long time to command a greater price in foreign markets than those of any other country.

The Chinese likewise manufacture velvets; but, if we are to judge from the specimens which have been imported into Europe, their success in this branch has been but very moderate, the quality of Chinese velvet being far inferior to even the most indifferent of European production.

This very beautiful fabric may be said to have a compound texture. In addition to the warp and shoot, of which the substance of plain goods is formed, velvet has a soft shag or *pile*, occasioned by the insertion of short pieces of silk thread doubled under the shoot, and which stand upright on its upper surface, in such a multitude, and so crowded together, as entirely to conceal the interlacings of the warp and shoot. It is this pile which gives to velvet its characteristic appearance, as well as that remarkable softness to the touch, which distinguish it from all other manufactured substances, and which, while it would be difficult to explain them in any intelligible terms, have themselves served for describing other bodies which present appearances or qualities somewhat similar to the sight and feeling.

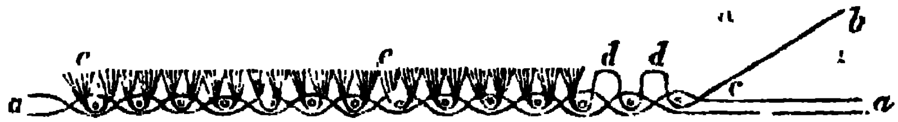
The beauty of velvet results, in a great degree, from the uniform evenness of its pile; and this, of course, depends upon the perfect equality in length of the threads whereof it is composed. All inequalities of this kind are rendered at once apparent to the eye, detracting materially from the elegance and value of the goods; and this circumstance calls for more than the ordinary degree of carefulness on the part of the weaver.

The pile, or, as it is technically but corruptly called by the weaver, the pole, is, of course, inserted during the operation of weaving the warp and shoot; and its insertion is thus effected: —

The loom being prepared, or mounted, as for the weaving of plain silk, another set of threads is provided, to run in the same direction with the threads of the warp. The two sets of threads are kept effectually disengaged from each other, by causing those which are to form the pile to rise diagonally from the breast-roll, through the whole extent of the porry, that is, through the space between the breast-roll and the yarn-roll of the loom.

Over the last of these is placed another roll; and with this the threads of the pile are connected, in the same manner as are the threads of the warp with the yarn-roll, and the delivery of the pile threads from this roller is governed similarly to the delivery of the warp threads, by means of a regulating weight. There is an absolute necessity for keeping the warp and pile distinct and independent of each other, which will be very evident, if it is considered that the lineal quantity of the latter which goes to the production of a given measure of velvet must be very greatly more than that of the warp threads. In point of fact, with every yard of velvet that is produced, six yards of the pile are required to be used.

Fig. 34.



The above diagram exhibits the structure of velvet, and the mode of combining the threads of the shoot with the pile. The texture is shown as if loosened, for the purpose of displaying the various parts with greater distinctness. *a a* are the warp threads, and the dots or small circles which occur in the loops representing the woven part, are sections of the threads that form the shoot; *b* shows the pile threads, which meet the threads of the warp in the angle *c*. Into this angle the weaver inserts a brass wire, so that it occupies a position through the whole breadth of the goods, below the pile threads and above all the threads of the warp; when the treadles being put into action, and the alternate threads of the warp raised, the shuttle is thrown, passing over the pile threads and the depressed half of the warp; the batten is then struck up against the shoot, thus accomplishing the requisite interlacing of the warp and shoot, and forming a loop of the pile thread over the wire. This wire is peculiarly formed, having one of its sides flattened, and a groove cut through its entire length, the form and situation of which are shown by the following section.

Fig. 35.

The shuttle is thrown three times between each insertion of the wire: the first shoot is of coarser thread than that which is used for the other two shoots, and, when struck up by the batten, causes the wire to take its proper position with the flattened side down, and its sharper edge towards the cloth-roll. *d d* show the loops thus formed. By running a sharp instrument called a trevat along the groove of the wire, these loops are then divided in the manner described at *e e*, and the whole operation of velvet weaving has been effected. It is necessary to use two wires, so that one may always remain in the cloth when the hinder one is cut out, otherwise the pile threads in the porry would be set at liberty, and the whole operation deranged: but by keeping one wire always inserted and secured in its place by three threads of shoot, the pile is sufficiently connected with the texture to prevent such an accident. The liberated wire is now again inserted; and when in its turn this has been secured by three casts of the shoot, the other wire is cut out, and so on alternately. The richest velvets were formerly woven with thirty-eight loops, caused by as many insertions of the wires, in every inch; but this branch of silk manufacture, encouraged by the greatly increased demand, and participating in the general improvement now experienced, as many as fifty-five insertions of the wires are made in the small space just mentioned.

The circumstance above mentioned, of the employment of threads of different degrees of fineness to compose the shoot, renders it, of course, necessary to use two shuttles, which must be exchanged for each other at constantly recurring but unequal intervals. It has indeed been shown, that the weaver of velvet requires to exercise an unintermitting carefulness in the succession of operations which he has to conduct. The use of the trevat in cutting the pile calls for a certain amount of skilfulness or sleight of hand, only to be fully acquired through care and after long practice, while the minutest deviation from the proper line in performing this part of the process would infallibly injure, if even it did not destroy, the goods; and the movements to be made throughout the entire operation are, as has been shown, so numerous, and require such constant changing of the hand from one action to another, that the weaver is greatly and unavoidably retarded in his progress. It is considered to amount to a very good day's work, when as much as one yard of plain velvet has been woven. For this the workman is usually paid five times the price charged for weaving gros-de-naples.

The warp and pile of velvet are both composed of organzined silk, and it is evident that its richness depends upon the relative number of its pile threads; the manufacturers are accordingly accustomed to designate velvets of different degrees of richness, as velvet of two, four, or six threads, according to the number of pile threads which are inserted between each of the dents of the reed.

An inferior description of velvet has of late years been composed of cotton. One of the principal uses to which this is applied, is that of ornamenting articles of household furniture, such as window hangings, which are not exposed to close inspection, or subjected to much wear, the difference of quality between it and silk velvet being immediately discernible.

Velvet is sometimes woven with stripes which run in the direction of the shoot, and which are produced, at regular intervals, by leaving uncut such a number of loops of the pile as are sufficient to make up the breadth of the intended stripe. The wire employed for forming these uncut loops is unlike that described, being of a simple cylindrical form: the appearance of velvet thus woven is rich and pleasing.

It has been already said that velvets should be manufactured throughout, warp, shoot, and pile, of soft organzined silk. This condition is not, however, always adhered to by foreign weavers of velvet; and, in particular, some goods have been brought to this country from Germany, the pile of which is composed of what is called *souple,* which is silk dyed in the gum. By the employment of this article, which contains an admixture of foreign matter, a less quantity of silk is made to suffice in forming the pile; but it is evident that the apparent richness will soon disappear, and the real inferiority of quality attendant upon this procedure will manifest itself to the wearer after only a very short acquaintance with his purchase.

CHAP. VII.

GAUZE WEAVING.

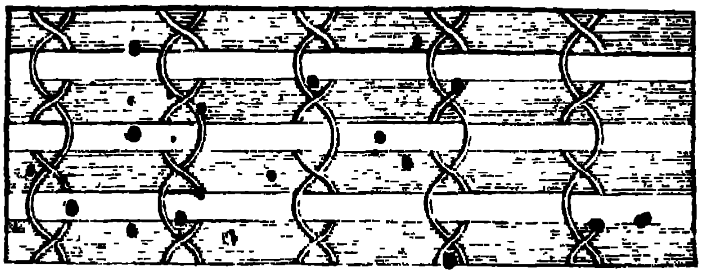
ITS ORIGIN. — STRUCTURE. — PECULIARITY OF ARRANGEMENTS IN WEAVING IT. — MODE OF PUTTING THESE IN ACTION. — DIFFICULTY OF THE PROCESS. — SUPERIORITY OF THE FRENCH IN GAUZE WEAVING — ACCOUNTED FOR.

Gauze is a very light and transparent fabric. The etymology of its name has caused it to be conjectured that we are indebted for its invention to Gaza, a city of Palestine, on the frontiers of Egypt, which, although now of only small extent, was formerly a place of considerable magnitude and celebrity. The manufacture of silk gauzes was, some years ago, very extensively prosecuted in the district of Spitalfields, but has of late been almost wholly discontinued in that quarter, and is principally transplanted to Paisley, near Glasgow, and the neighbouring villages in the counties of Lanark and Renfrew.

The particular arrangements used in the production of this tasteful fabric are known among the craft under the title of cross-weaving. In all the species of interlacings hitherto described, whatever the order of succession wherein the warp threads may be alternately raised and depressed, they always remain parallel to each other, and without twisting or crossing; whereas it is the essential character of gauze, that between each cast of the shuttle such a crossing of the warp threads shall ensue, as while it admits of each shoot being in its turn struck up by the batten with the degree of force necessarily required to impart to it stability and regularity, yet prevents its being carried thereby into absolute contact with the shoot immediately preceding; the intervals thus left between the interlacings causing that degree of transparency, which, without these crossings, could only result from a looseness of texture altogether incompatible with beauty and utility.

In the following diagram, the unshaded cross lines must be taken to represent the shoot, while the twisted lines, whereby they are intersected and embraced, are descriptive of the warp threads. It is evident that the twisting thus given must effectually prevent the too close approximating of the successive shoots, without being in any respect incompatible with the needful regularity of their positions, or with a due degree of stability. The diagram is necessarily drawn upon an exaggerated scale, in order to render the peculiarity of the fabric at once apparent upon inspection.

Fig. 36.



To produce the appearance here given, it is not necessary that the adjoining warp threads should be actually crossed at each casting of the shuttle, as the return of the threads from the crossed to the parallel state will have the same effect as giving a reversed crossing. The twistings are made alternately to the right and the left hand; and each twist, as it is produced, is kept by the striking up of the shoot with the batten.

It would not be possible, within the necessary limits, and without having recourse to numerous drawings, to communicate with sufficient clearness all the minutiæ of arrangement upon which gauze weaving is made to depend. It will, perhaps, suffice to impart a general idea of the principle upon which it is conducted, if reference is had to the following diagrams.

Fig. 37.

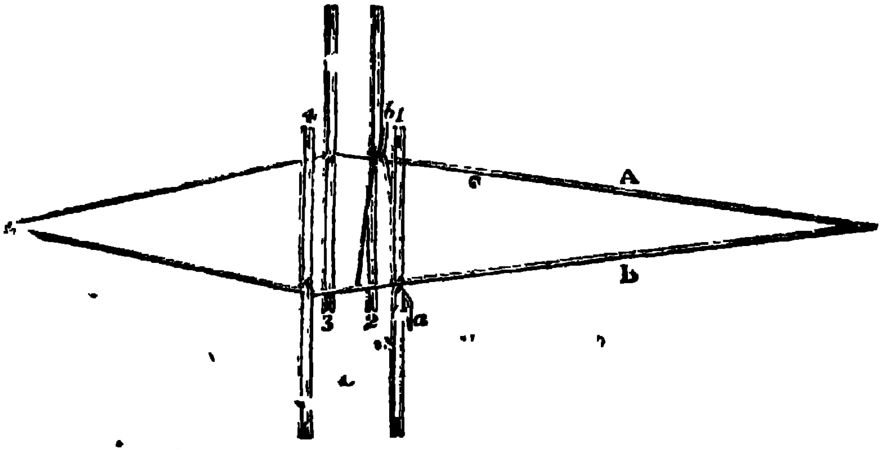


Fig. 38.

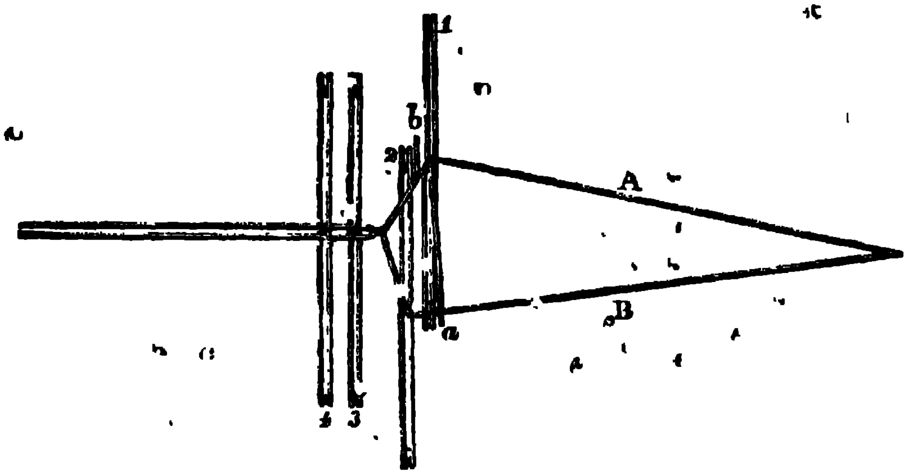
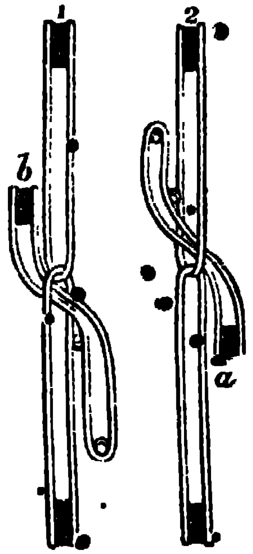


Fig. 37. represents two warp threads, A and B, opened to form the shed in the ordinary manner of plain weaving, and *fig.* 38. shows the same threads when the requisite crossing has been accomplished. The same letters and figures refer to corresponding parts in the two diagrams.

The mounting of a gauze-loom consists of four heddles, or leaves of heddles, and of two half leaves. The open shed is formed by the leaves numbered 3 and 4, and the cross shed by the leaves numbered 1 and 2, which are called standards, and by the half leaves *a* and *b*, which pass through them in the manner here represented.

In order to produce the twist in forming the shed, the warp threads do not rise and sink alternately, or at regular intervals, as in plain weaving or in twilling, the

Fig. 39.



thread A being always raised, and the thread B as constantly depressed. On examining the figures, it will be observed that the thread A is drawn through the third leaf of heddles, and as it always rises, is not taken through the loop of the heddle or the mail, but above it, through what the weavers usually call the upper doup. The thread B is drawn through the fourth leaf of heddles, and because it always sinks, is drawn through its under doup. One of the two half leaves is hung from above, and the other is attached below. That from above *b* passes through the lower doup of the standard, numbered 2; and the half leaf *a*, which is attached below, passes through the upper doup of the standard, numbered 1, as is plainly shown by *fig.* 39. The warp thread A is drawn through the under half leaf connected with the standard numbered 1, and the thread B passes through the upper half leaf connected with the standard numbered 2. The alternate crossings of the warp threads are occasioned by the action of the half leaves; these, in *fig.* 37., would work in opposite directions to the standards, and leave room for the warp to rise or sink in the space between them and the heddles; but in *fig.* 38. the half leaves rise and sink with the standards through which they are respectively passed, and one thread of the warp is necessarily forced across the other. All this may be ascertained by carefully tracing the warp threads in their passage through the various divisions of the harness, as described in the foregoing diagrams. The dots seen in *fig.* 39. represent sections of the warp threads A and B.

The heddles and standards are moved by two treadles, the depression of which in this mode of weaving calls for more than the ordinary amount of exertion; especially when the weather is damp, the labour is so much increased that the weaver can make only slow progress with his work. Another evil attending this kind of weaving is, that the increased friction to which the silk threads are subjected occasions them very frequently to break — much more frequently than in any other kind of weaving — and the arrangements render their repair a much more troublesome operation. To remedy this, it was usual formerly to pass the warp threads through the eyes of glass beads; but this was a troublesome and tedious process, and, joined to the difficulty of properly confining the beads, has induced the weavers to discontinue their employment.

Gauze is one of the very few articles of silk manufacture in which it is held that the French weavers still bear away the palm from ours; a fact which is, doubtless, referrible to the lower rate of wages paid on the other side of the Channel. The weight of silk contained in a yard of gauze is very trifling; and the value of the material bears a much smaller proportion to that of the labour consumed in its conversion, than is borne by weightier fabrics.

CHAP. VIII.

BROCADE, DAMASK, ETC.

GOLD AND SILVER BROCADE. — METALLIC THREADS. — GILT AND SILVERED PAPER. — DAMASQUITTE. — MACHINERY EMPLOYED IN ITS PRODUCTION. — METHOD OF RESTORING TARNISHED BROCADE. — SILK BROCADE. — DAMASK. — ITS MANUFACTURE BROUGHT TO ENGLAND. — MODE OF MANUFACTURE. — CAFARD DAMASK. — PERSIAN. — SARSNET. — GROS-DE-NAPLES. — DU CAPE. — SATIN. — CRAPE. — LEVANTINE. — GROS-DES-INDES. WATERING. — EMBOSSING, MIXED GOODS. — BOMBAZINS. — POPLINS. — LUSTRES. — SHAWLS.

The highly ornamented and rich brocades in which our great-grandmothers used to find such delight have now entirely disappeared from use, and, indeed, scarcely exist for us, except in the verses of our poets or the essays of satirists of those days. It would be useless, therefore, to attempt giving a description of the mode of manufacturing articles so apparently consigned to oblivion, if it were not for the probability that, in some of the ceaseless mutations of fashion, these sumptuous fabrics may yet once again lay claim to admiration in our drawing-rooms, to the exclusion of the less substantial and less gaudy finery with which the fickle leaders of public taste are now satisfied.

In ancient times, those cloths only were called brocades which were woven, both in the warp and shoot, with gold or silver threads, or with a mixture or combination of both these materials. In preparing the threads for manufacturing gold brocade, a flattened silver-gilt wire or riband was spun on silk that had been dyed, to resemble as nearly as possible the colour of the metal; and the principal excellence in the art of preparing gold threads consisted in so regulating the convolutions of the metallic covering of the silk, as that its edges should exactly touch, and form, as it were, one continued casing, without either interval or overlapping.

At the time when the weaving of these golden tissues was encouraged by public taste, the manufacture of the threads, whence they were produced, had arrived at a high degree of excellence. At Milan there was a considerable manufactory, in which, by a secret process, flatted wire was made, having only one side covered with gilding. Threads of an inferior description were also made, chiefly at Nuremberg, by spinning gilt copper wire upon threads of either flax or hemp; and the Chinese, still more economical, used slips of gilt paper, which they twisted upon silk, and sometimes even introduced into their stuffs, without thus giving to the paper any fibrous support. But these productions could have boasted, at best, only an evanescent beauty; and, accordingly, we learn from Du Halde, the historian of China, that golden tissues were rarely used in that country, except for tapestries, or other ornamental substances, which were but little exposed to view, and could be effectually protected from moisture.

In process of time, silken threads, uncovered with metallic wires, were used to form the plain ground of brocades, upon which gold or silver flowers, or other ornaments, were raised; and at a still later period, fabrics composed entirely of uncovered silk, provided they were adorned and worked with flowers, or other ornamental figures, equally took the name of brocades.

There was a very considerable and flourishing manufacture of brocades carried on during the thirteenth century in Lucca; but, in the year 1310, by the insensate tyranny of Castruccio Castracani, as related by his biographer, the celebrated Machiavel, the artisans thus engaged were driven from that city; and 300 of these retired to Venice, where, encouraged by the offer of many privileges, they recommenced their manufacture. For a considerable time after this the Venetian manufacture was carried on with the raw material brought from Sicily and the Levant, the cultivation of the mulberry tree, and the breeding of silkworms, not having been adopted to any extent in that quarter earlier than the sixteenth century.

In the course of the last century, the Venetians invented a modification of brocade, and in this new manufacture, which they called "damasquitte," they at one time carried on a very extensive trade. Although these stuffs actually contained not more than half the quantity of gold or silver employed in making brocade according to the usual method, they yet looked far more beautiful. The flatted wires were not wound so close together on the silk threads, nor were there so many of these threads used in the weaving; but, by passing the stuffs, when manufactured, between rollers, to which a great amount of pressure was given, the wire threads were partially crushed, so as to cause the ornamental pattern to assume the appearance of one unbroken and brilliant plate of gold or silver.

The process whereby this degree of pressure was communicated was for a long time kept carefully enveloped in mystery by the Venetian manufacturers. The advantage derived by the state of Venice from this manufacture at length drew the attention and excited a spirit of rivalry on the part of the French government, who engaged the celebrated Monsieur Vaucanson in the endeavour to contrive machinery for producing similar fabrics. In this attempt he proved successful; and we are indebted to the published memoirs of the French Academy for the year 1757 for an account of his success, and of the machinery employed by him in the manufacture at Lyons.

The cloth was passed between rollers, the lower one of which was made of wood, thirty-two inches in length and fourteen inches in diameter. The upper roller was of copper, thirty-six inches long, and eight in diameter; the last was made hollow, and it was open at one end, for the introduction of iron heaters. Both the rollers were made, as nearly as possible, in the form of perfect cylinders. In his first attempts to work with these rollers, Monsieur Vaucanson found that the exerted force of ten men was barely sufficient, and that for only a short time, to turn them with force enough properly to extend the plating of the wire threads; and, by the excessive pressure used, the collars in which the axes of the rollers turned were worn so fast, and to such a degree, that the pressure was constantly and progressively diminishing, so that a piece of stuff of twelve yards had the gilding visibly less extended on the last than on the first yard, and the machine was constantly subject to disarrangement. It was attempted to lessen this evil by screwing up the rollers towards each other during the progress of the pressing; but this was objectionable, because, for every turn that was given to the tightening screws, a mark or bar invariably appeared across the cloth. To lessen the wearing away of the bearing collars, anti-friction wheels or rollers were provided, between which the axes of the rollers were made to turn; but this remedy produced an evil of another kind: the wooden roller, which, from the nature of its material, was susceptible of compression, had its cylindrical form so altered, that the effect upon the cloth varied in every part of the revolution. It was in vain that the ingenious inventor made trial of different kinds of wood for constructing the roller: if this was hard, it invariably split, and if soft, it warped; so that of twenty rollers formed from different kinds of wood which were tried, not one continued cylindrical during twenty-four hours' work.

These failures induced M. Vaucanson to contrive a method of forcing the rollers together, so that the pressure should always accommodate itself to any inequalities that might occur in the work, or in the bearings of the machine. The axis of the copper roller was made to turn, as already mentioned, between anti-friction rollers, while the wooden roller was pressed upwards by levers placed one at each end. Each of these levers had the end of its short arm supported on the frame of the machine, and the long arm drawn upwards by an iron rod which communicated with the short arm of another lever placed horizontally, while to the long arm of this last-mentioned lever a weight was hung, and these levers were so proportioned, as that when the weight thus employed was only of thirty pounds, the rollers were pressed together with a force equal to the weight of between 17,000 and 18,000 pounds, which was found to be the force required and best adapted to the due extension of the plating. By this arrangement, the strength of four men was found to be more effectual in turning the rollers than that of ten men had proved under the first attempted method; and as the same weight acted uniformly during the entire revolutions, the pressure was always equal, even although the wooden roller should have varied in its shape, and notwithstanding any inequality that might occur in the thickness of the goods.

Four iron bars brought to a red heat were introduced within-side of the copper roller, which became in half an hour nearly as hot as the utensil commonly employed by laundresses in ironing linen. After two, or at the most three pieces of cloth had been passed through the rollers, it became necessary to change the wooden one for a fresh roller of the same material, as the heat, if long continued, occasioned a great tendency to splitting. The degree of heat necessary for properly extending the gilding, although it improved the brilliancy of white and yellow silks, was highly injurious to fabrics of certain other colours, and particularly to such as were crimson or green. The only remedy for this, and indeed it did not amount to a remedy, but was only a palliative, was to pass the stuff through from between the rollers with the greatest possible celerity. M. Vaucanson recommends, that on the removal of the heated wooden rollers, they should immediately be wrapped in cloths, and placed in an atmosphere from which they may acquire moisture.

Brocades, into the composition of which metals were admitted, were very liable to become tarnished: when this had taken place, they could be restored to all their original lustre by washing them with a soft brush dipped in warm spirit of wine. This appears to be the only material suitable for the purpose: alkalis, and even soap, would be improper; the former as they would injure the texture of the silk, and both as they would hurtfully affect certain of its colours. Some descriptions of powders have been recommended for restoring the faded beauty of brocades, but however fine these may be ground, and however carefully they may be used, they must still, from the very mode of their operation, scratch the metal; and this, especially with goods prepared according to the last described process, is of an extreme thinness, so as to be easily worn away, when of course the whole beauty of the fabric would be destroyed.

Brocades of silk were, at the commencement of the last century, exceedingly admired and much used among the luxurious votaries of fashion of both sexes in England. We may learn in what degree this finery was then estimated, by consulting the pages of Pope and Addison: the former in the second canto of his elegant and lively satire, "The Rape of the Lock;" and the latter in the fifteenth number of the Spectator, where it is stated that, among the fashionable ladies of that period, "a furbelow of precious stones, a hat buttoned with a diamond, a brocade waistcoat or petticoat, are standing topics of conversation; that lace and ribands, silver and gold galoons, with the like glittering gewgaws, are so many lures to women of weak minds, and when artificially displayed, are able to fetch down the most airy coquette from the wildest of her flights and rambles." Fearing, perhaps, lest in thus censuring his fair countrywomen for a foible which had usually been considered as characteristic of the sex, and not confined to any particular age or country, he might be chargeable with an unfair severity, the moralist goes on to relate how Camilla, the queen of the Volsci, after exhibiting her absence of all feminine softness by placing herself at the head of an army, that she might assist king Turnus in his war against Æneas; and after having, with her own hand, slain numbers of the enemy, still allowed all the woman to reveal itself in this particular: — "She unfortunately cast her eye upon a Trojan who wore an embroidered tunic, a beautiful coat of mail, with a mantle of the finest purple. 'A golden bow hung upon his shoulder, his garment was buckled with a golden clasp, and his head covered with a helmet of the same shining metal.' The Amazon immediately singled out this well-dressed warrior, being seized with a woman's longing for the pretty trappings he was adorned with : —

> ———— totumque incauta per agmen,
> Fœmineo prædæ et spoliorum ardebat amore." [*]

For some time after the use of brocades for garments had been discontinued, these substantial fabrics continued to be employed for ornamental articles of furniture ; and as late as the year 1788 some very elegant pieces were woven in Spitalfields, to be used as chair bottoms in Carlton House. These specimens of the art are still in existence, and prove that the discontinuance of the use of brocades must not be ascribed to any deficiency of ability on the part of our artisans, who, on that occasion, exhibited a degree of skilfulness in their labours fully equal to any shown by earlier and similar productions.

Silk damask was formerly extensively used both for garments and ornamental furniture. Applied to the latter use, this manufacture is still frequently met with in the dwellings of the opulent ; and it is probable that some of the depositories of our careful dowagers might yet be made to reveal habiliments which have been displayed at levees and drawing-rooms, exciting the envy and admiration of our progenitors.

While we cannot but wonder at the taste which influenced the worshippers of fashion in the olden days to incase and conceal their figures beneath the formal folds of such unyielding fabrics, we do not reflect upon the probability that our most elegant costumes may, in their turn, become the objects of surprise and derision to our great-grandchildren, and that even the graceful draperies of Lawrence may in their eyes appear as formal and grotesque as are the once-admired vestures of sir Peter Lely to our own.

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[*] Æn. lib. xi. 781.

It has been supposed, and the etymology of its name would seem to favour the supposition, that this branch of the weaving art was originally brought to the westward from Damascus. It has been very long followed both in France and Italy, while its introduction to the looms of England appears to have taken place at a very early period of the annals of our silk manufacture; and is said to have been occasioned by the flight to these hospitable shores of certain Dutch and Flemish weavers from the persecutions of the duke of Alva, when, in the year 1567, he was deputed by Philip II. of Spain to extinguish the kindling spark of liberty in the Low Countries; affording thus another historical evidence of the beneficial influence upon society, of circumstances which, at the time of their occurrence, appeared to be fraught with unmixed and unmitigated evil.

The expensive nature of this manufacture caused it to be principally confined to the use of the high-born and wealthy of the land; but on occasions of great ceremony people in the more middling walk of life could still display silk damask garments, which during the interval of these occasions were carefully preserved, so that they were frequently handed down from one generation to another as heir-looms of the family. Silk damask never, in fact, became of common use; and when, a full century after the first introduction of its manufacture to this country, our celebrated Locke published his "Considerations on lowering the Interest and raising the Value of Money," we find that he noticed this as an article of almost unwarrantable luxury.

When wrought with a great variety of colours, damask furniture had certainly a very elegant effect; but it has not for a long time been usual to employ more than one colour in damask hangings, and their elegance now consists wholly in the richness of the material, and the taste displayed in the pattern.

Damask is a twilled fabric; the appearance of its texture is familiar to all, from its identity with that of the beautiful linen table services, the manufacture of which has long been carried on to a great extent in Scotland, and more recently on a smaller scale in Ireland. The weaving of these calls into exercise all the skilfulness of the weaver in mounting his loom, to the great labour attending which is, in a great measure, owing the expensiveness of the manufacture. The designs, which are frequently very extensive, comprising upwards of 1200 changes for their completion, are laid off upon paper lined into very small squares, in a manner already described, and this serves as a guide in mounting the loom. To present such a description as would be intelligible and satisfactory, of this art of designing and mounting in the draw-loom the elaborate patterns which are so generally met with in damask table-cloths, would require more space than can well be allotted here to an object which, as regards the particular subject of this work, is of very minor consideration, and which applies more importantly to the manufacture of linen than of silken fabrics.

The French had long since a manufacture in imitation of the old fashioned silk damask, which they called *Cafard* (counterfeit) damask: this, while it had its warp composed of silk, had the shoot of either thread, wool, or cotton, and sometimes even of hair. These stuffs were not without a considerable degree of beauty ; and a similar mixture of materials is generally employed in the damask hangings which are manufactured in the present day.

There are several descriptions of silk goods, or, to speak more correctly, several modifications of the same class, which are each known popularly by distinctive names, but which yet require no particular description. Thus the plainest mode of silk-weaving takes the name of Persian, sarsnet, gros-de-naples, ducapes, &c., varying only in the thickness of the fabric, or the quality of the material of which it is composed, and not at all differing in the arrangements of its interlacings.

The quality first mentioned is exceedingly flimsy in its texture, and has of late nearly gone out of use, its place being taken by the description next in quality, sarsnet. This, which used to form the substance of garments, is now most usually employed for lining them, giving place in its turn, as regards its former more dignified uses, to gros-de-naples. This last is made of stouter and harder thrown organzine silk, and is put together with more care and labour, containing a greater number of threads, both warp and shoot, in a given surface. Ducapes are likewise plain-wove stout silks, but of softer texture than the last.

Satin is a twill of a peculiar description: the soft and lustrous face which it exhibits is given by keeping always a very large proportion, frequently even as much as seven out of every eight threads of the warp, visible, or as it is called, floating above the shoot. Satin is always woven with the face downwards, the labour of the weaver being thereby abridged, because it is easier to raise the harness connected with one eighth, than it would be to raise seven eighths of the warp with every cast of the shuttle.

It can hardly be necessary, after the particular description already given of the mode of producing twilled silks in general, to repeat any part of it here, by entering into the minutiæ of satin-weaving. It is plain that every peculiarity attendant upon this falls within the compass of the Jacquard machine, by means of which figured satins of the most beautiful textures and patterns may be manufactured.

When satins are first taken out of the loom they exhibit a certain degree of roughness or flossiness, owing to the comparative infrequency of the interlacings of the shoot with the warp. To remedy this, they are dressed by being rolled on heated cylinders; which operation smooths down the face of the goods, and imparts, at the same time, that beautiful lustre which is so attractive.

Satins from China are much esteemed for the quality they possess of being easily cleaned and bleached, when they resume all their original lustre; but in other respects they are found to be inferior to those manufactured in Europe. Satins of the higher qualities have long been manufactured in Spitalfields, for the supply of our eastern dependencies.

Crape is a light and transparent article of plain weaving; it is made with hard silk of the natural colour, and the peculiar appearance which it is made to put on is given to it in the operations of dying and dressing after it quits the loom; a further quantity of gum being then added to the silk the threads are impelled, by the stiffness thus acquired, to unwreathe the twist which had been given to them in the mill, and hence the apparent irregularity of texture assumed by crape. This may be easily proved by washing it in water hot enough to discharge the gum, the fabric will then assume an appearance very similar to that of gauze. The warp of crape is usually composed of singles; the shoot is frequently formed of the same material; and sometimes, when it is wished to make it of closer texture, of two-thread tram, the two threads, by partially untwisting, then give a more crinkled and intricate appearance to the cloth.

Crape, from its sombre appearance, has always been considered as adapted to mourning vestments. Different manufacturers affect a degree of mystery with regard to their peculiar modes of dressing crape, possessing or imagining thence some superiority over their rivals in the manufacture.

Many of the numerous titles by which silken fabrics are known denote such minute distinctions that it would be both tedious and useless to offer any particular descriptions concerning them. Every variation in the order of succession in the harness used in weaving, or, as it is termed in the weavers' language, every different tie, produces a different pattern, which is thought deserving of a distinctive name. Most of the fabrics more generally used have already been described; and when it has further been explained that levantine is a stout, close-made, and twilled silk, and that gros-des-indes is formed by using different shuttles with threads of various substances for the shoot, whereby a stripe is formed transversely to the length of the goods, there then appears to be nothing more required under that head of information.

The process which is called watering silk, and which gives to its surface a peculiar and unequal wavy appearance, is effected by placing together, lengthwise, one on the other, two pieces of silk, and passing them, thus circumstanced, between two cylindrical metal rollers, one of which is made hollow for the purpose of containing a heated iron in its cavity. Smooth and even as the surface and texture of the woven fabric appear to our imperfect vision, it has in reality many thicknesses and as many inequalities as there are crossings of the warp and shoot. These inequalities are not brought to coincide in the two pieces of silk when they are placed together, so that such portion of the face of each as is thereby subjected to severer pressure will receive a greater gloss or polish than other portions, and the wavy appearance results entirely from this unequal degree of pressure. The appearance here described is sometimes produced when it is not wished to do so, and is the result of an unequal pressure used in winding the woven silk upon the breast roll of the loom. The only means of preventing this accident is by using a proper degree of carefulness in rolling the silk.

The surfaces of plain silk goods, and particularly of ribands, are sometimes embossed, so that very elegant patterns are produced upon them. This operation is likewise performed by passing the silk between rollers, the surfaces of which contain the pattern which it is intended to produce. In one of the cylinders the pattern is sunk, and in the other raised, so that the eminences of one coincide exactly with the cavities of the other cylinder. This process has of late been very extensively employed for ornamenting waistcoat patterns, producing a very rich and tasteful appearance; but it can be more appropriately applied to ribands or other fabrics which are not much exposed to friction; the inequalities of surface are otherwise found to be unfavourable to the durability of the material.

In addition to the fabrics woven of silk alone, there are other goods into the composition of which this beautiful material is made partially to enter, and which, in legal phraseology, are denominated mixed goods. The most common of these is bombasin, which is a twilled manufacture, having its warp of silk and its shoot of worsted.

The use of this article was at one time restricted to the making of mourning garments; but at a later period, no longer condemned, like the gondolas of Venice, to wear alone the sable hue of night, bombasins appeared in colours as gay and as various as the Protean wand of fashion could call forth. Their manufacture, which once employed a vast number of looms in Spitalfields, has for some time been almost wholly confined to the city of Norwich. Bombasins are all woven grey, that is, with silk of the natural colour, and they are dyed in the piece after being taken from the loom.

Poplins and lustres are likewise composed partly of silk and partly of worsted, with a somewhat larger proportion of the former material than enters into the composition of bombasin: they are plain woven goods. Poplins were manufactured of exceedingly fine qualities in Dublin, which city had formerly a very favourable trade in them, but both these articles have now nearly gone out of use.

Norwich has long been celebrated for its manufacture of shawls, wherein silk forms a part in combination with either cotton or worsted; it is only of late years, however, that these manufactures have attained to the high degree of excellence which now characterises them, or that they have been brought in respect to price so completely within the reach of the more humble ranks. It is to these coinciding merits of beauty and cheapness that the shawls of Norwich owe their general introduction into foreign countries. It may indeed be said, with reference to these mixed goods generally, that our country stands in every way without a rival.

PART IV.

CHEMICAL, MEDICAL, AND ELECTRIC PROPERTIES OF SILK.

COLOURING MATTER OF THE COCOON. — MANNER OF BLEACHING SILK PROPOSED BY BAUMÉ. — ENGLISH METHOD OF BLEACHING. — "THE BITTER PRINCIPLE." — VARIOUS CHEMICAL EXPERIMENTS. — GUTTÆ ANGLICANÆ. — SILK A PROTECTION AGAINST MALARIA. — FORMERLY USED AS A MEDICINE. — ITS ELECTRIC PROPERTIES. — HOW FIRST DISCOVERED. — VARIOUS EXPERIMENTS DETAILED.

The colouring matter, which more or less tinges silk with a golden hue, resides in the gum which the silkworm produces in such abundance with the filament, and which exercises so important an agency in facilitating all the preliminary processes of its manufacture.

If the cocoons be immersed in hot water a portion of this gummy or resinous substance will be dissolved, and will impart to the water a light amber colour. If alcohol be employed as the solvent a much larger portion of this matter will be extracted from the silk, and a tincture formed, which will retain its colour even after it has been exposed to the rays of the sun for a much longer time than would suffice to bleach the silk itself.

The knowledge of the fact that this colouring matter has a greater affinity for alcohol than for water led Mons. Baumé to adopt the following process for bleaching silk: —

A stone-ware vessel, of a nearly conical form, and capable of holding about twelve gallons, was provided; having a large opening at the top, and a smaller one, about an inch in diameter, at the bottom. Vessels made of common pottery-ware could not be used for the purpose, as they would speedily have been rendered unserviceable by the acid employed in the bleaching. From the same cause, the stone-ware even proved to be not very durable. All roughnesses on the inside surface of the vessel, which could have broken the threads of silk, were carefully rubbed down with pumice-stone. The small aperture at bottom was closed by a cork, through the centre of which a glass tube, of a quarter of an inch diameter, was passed, and, except at the time when it was required to draw off the liquid contents of the vessel, this tube also was kept closed by a cork.

Six pounds of yellow raw silk were then disposed in the stone-ware vessel, and upon this was poured a mixture previously made of forty-eight pounds of alcohol (specific gravity 0·867), with twelve ounces of very pure muriatic acid (specific gravity 1·114). The vessel was then completely closed, and the whole was left in digestion until the liquor, which at first assumed a green colour, passed to that of a dusky brown: this usually happened in the course of twenty-four hours. The acidulated spirit was then drawn off by means of the glass tube. and clean spirit of wine was poured continually over the silk, until the liquid passed off perfectly colourless. The silk was then left to drain without being otherwise disturbed. A mixture of the same quantity of spirit with muriatic acid was then again poured upon the silk, which, after being exposed to its action for a period somewhat longer than the first digestion, proved to be perfectly and brilliantly white. The time required for this second application of acidulated spirit was of less or greater duration, according to the temperature, and the original quality of the silk. Baumé found that the bleaching was much more readily accomplished when the cocoons had not been previously baked, for the destruction of the chrysalides. The second dose of liquid was but slightly tinged when drawn off; and if another portion of acid, equal to half the quantity originally used, were added to it, the mixture could properly be used for the first digestion of a second quantity of the raw material.

A further washing of the silk then ensued, by pouring upon it forty-eight pounds of pure unacidulated spirit of wine, which was drawn off in the course of the following day.

To recover the quantity of spirit absorbed by the silk, and which was equal to its own weight, small quantities of water were sprinkled over it from time to time, and this process was continued until the liquid, which drained off through the glass tube, had no perceptible strength. Notwithstanding these repeated washings, the silk still retained a portion of muriatic acid, which made it harsh to the touch, and if left in it, would, after a time, have injured its fibre: it was therefore placed in a coarse woollen bag; and this, being enclosed in a basket, was left for several hours in a stream of running water, which effectually washed out the acid.

Pieces of manufactured silk, and even made-up garments, have been successfully bleached by this process.

The spirit may be recovered by saturating the mingled acid with potass, or lime, and then distilling the spirit in a copper alembic. Mons. Baumé says that silk may be thus made to rival or even to surpass in whiteness and lustre the finest specimens from Nankin.*

The revenue regulations, and the dearness of spirit, make the above process impracticable in England, where the usual method of bleaching raw silk is to immerse it in a boiling solution of good soap in river water. After boiling for two or three hours the silk is taken out, beaten, and then rinsed in cold water; when this has been sufficiently performed, it is slightly wrung, then put into cold soap and water, tinged with a minute portion of indigo, and again boiled. On removing the silk from this second water, it is wrung as dry as possible with the assistance of wooden pegs, and is then well shaken to separate the threads: after this it is suspended in a kind of stove constructed for the purpose, which contains sulphur in a state of combustion; the fumes arising from this give the last degree of whiteness to the silk, and the process is completed.

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* Ure's Dictionary of Chemistry, art. *Bleaching*. Annales de Chimie, tome xvii.

Silk is powerfully acted upon by nitric acid. If two drachms of this acid are mixed with a pint of alcohol, and silk, either raw or bleached, be immersed in it, and kept in digestion exposed to a moderate heat for twenty-four hours, the silk becomes of a dull yellowish brown, which, after it has been washed with soap, rinced, and dried, turns to a fine golden yellow colour, which is very permanent. Concentrated nitric acid being distilled off silk, and the remaining liquor partially evaporated, oxalic acid is obtained: if the evaporation be pursued still farther, the residue will yield, together with a small portion more of oxalic acid, a quantity of yellow crystals, not in the slightest degree acid, but intensely bitter, and which stain the skin of a deep yellow colour, not easily removed. This curious substance was discovered by Welter, and was called by him "the bitter principle." He supposed that its production always results from the action of nitric acid on animal matter. These crystals, when examined through a magnifying glass, appear to be composed of truncated octohedrons.

If the remaining liquor be previously saturated with potass and evaporated, another yellow silky salt separates, which detonates on burning coals like nitre, and appears to be a triple combination of the before mentioned bitter substance with nitrate of potass.

The water wherein the cocoons are placed to prepare them for reeling, quickly acquires from them so much of the resinous matter as to be more viscid than the strongest soap lather. Chappe found that he could inflate this water into bubbles or small balloons, which were far more permanent than any formed of soap and water, and which equally exhibited the prismatic colours. The texture of these bladders was so tenacious, as to render them impervious to the most subtle gas: Chappe filled several of them, whose diameter did not exceed three inches, with hydrogen gas, and the little air balloons remained unbroken and floating in his apartment for considerably more than twenty-four hours. All cocoons are not sufficiently glutinous for this purpose;

with those which are of a very deep yellow the experiment will not succeed: such are supposed to be produced by the worm in a peculiar state of disease, which state is yet by no means uncommon.

According to Westrum, silk, when acted upon by chlorine, either in the gaseous form or diluted in water, instead of being bleached, as cotton or linen would be, always becomes of a yellow colour, and loses part of its solidity. The caustic alkalis corrode and dissolve silk, which gives by distillation the results usual with animal substances.

Neumann found that but few materials afforded an equal quantity of volatile alkali. Tournefort observes that it contains more than hartshorn, as he obtained from fifteen ounces of silk two drachms of volatile salt: this, which was called the spirit of raw silk, when rectified with some essential oil, was the medicine formerly celebrated under the name of "Guttæ Anglicanæ," or English drops. The volatile alkali obtained from silk was then supposed to be of a different nature from that contained in any other substance, and it consequently was held to possess different virtues peculiar to itself. So salt of tartar, and sub-carbonate of potass, were for a long time considered to be, and were used as two separate substances. The chemical philosopher had not then learned to generalise, and could not understand that the same substance, differing in no one particular as to its nature and properties, could be obtained from many apparently wholly dissimilar bodies.

Before the discoveries of chemistry had arrested the fanciful flights and annihilated the quaint distinctions of the druggist, his catalogue presented a curious nomenclature, which is now acknowledged to have been founded on ignorance and prejudice. The light of science has since pierced the veil, and has revealed many of the laws of nature in all the beautiful simplicity of their elements; dispelling much of the complicated mystery and vague obscurity which then enveloped the ill understood practice of pharmacy.

A silk covering of the texture of a common handkerchief is said to possess the peculiar property of resisting the noxious influence and of neutralising the effects of malaria. If, as is supposed, the poisonous matter is received into the system through the lungs, it may not be difficult to account for the action of this very simple preventive: it is well known that such is the nature of malaria poison, that it is easily decomposed by even feeble chemical agents. Now, it is probable that the heated air proceeding from the lungs may form an atmosphere within the veil of silk, of power sufficient to decompose the miasma in its passage to the mouth; although it may be equally true that the texture of the silk covering may act mechanically as a non-conductor, and prove an impediment to the transmission of the deleterious substance.*

We learn from Pomet's history of drugs, that silk was in his time used as a medicine, by reducing the pure part of the cocoon into a powder. His volume contains many copious directions for preparing this powder, and for duly and carefully separating the chrysalis from the part which he considered medicinal. Silk thus prepared has, as he affirmed, "the virtues of cleansing the blood, making the spirits brisk, and the heart pleasant." Lemery, the editor and commentator of Pomet, adds, that the silkworm itself likewise possesses medicinal properties. According to his information, silkworms that had been dried into a powder and applied upon the head, which should be previously shaved for the reception of this plaster, were esteemed extremely efficacious in curing vertigo.

The imperishable nature of silk, even under circumstances peculiarly unfavourable to the preservation of animal substances, forms another of its qualities which is deserving of remark. Some years ago, the sexton of the parish of Falkirk, in Stirlingshire, upon opening a grave in the churchyard, found a riband wrapped about the bone of an arm, and which, being washed, was found to be entire, and to have suffered no injury, although it had lain for more than eight years in the earth, and had been in contact with a body which had passed through every stage of putrefaction, until it was reduced to its kindred dust.

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* Annual Register for 1829, vol. lxxi.

The discovery that silk is an electric, or a non-conductor of electricity, originated in one of those fortunate accidents to which science has been indebted for many of her most valuable discoveries. This fact it was which first led to the beautiful disclosure of the distinction between electrics and non-electrics.*

In 1729, while the knowledge of electrical phenomena was yet in its first infancy, Mr. Grey, after performing many interesting experiments, succeeded in conducting the electric fluid, excited by friction in a glass tube, through a perpendicular distance of many feet, by causing one end of a piece of iron wire or packthread to communicate with the glass tube, and the other end with an ivory ball. Pleased with his success, he became desirous of conducting the fluid horizontally; but this experiment failed at the time, through the mode of his attempting it, which was by carrying his line over a packthread cord, suspended for the purpose across the room. Through this material the electric stream escaped, and the ivory ball was, in consequence, no longer found to be excited.

Mr. Grey having communicated to a friend the ill success which had attended this attempt, was advised to suspend the conducting line by *silk* instead of *packthread*; there being no other reason for this advice than the greater fineness of the former. Acting upon this suggestion, their first experiment was made in a large matted gallery; a line, the middle part of which was of silk and the two extremities of packthread, was fastened across the gallery; the conducting line with the ivory ball at the end was passed over the silken portion, and hung nine feet below this horizontal line of suspension.

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* Note HH.

The conducting line was eighty feet and a half in length, one end being fastened by a loop to the electric tube; upon rubbing this, the experimenters had the gratification of finding that the ivory ball attracted and repelled light substances in the same manner as the tube itself would have done. They next contrived to return the line, so that the whole length amounted to 147 feet, and in this case likewise the experiment answered tolerably well; but suspecting that the attraction of the electric fluid would be stronger if the line were not doubled, they carried one straight forward through a distance of 124 feet. In this anticipation they were not deceived, the attraction under these circumstances being stronger than when the line was doubled. Proceeding thence to add more and still more to their conducting line, until at length the slender silk thread broke from the weight imposed, they sought to substitute for this fragile cord a small wire, first of iron and then of brass. The unsuccessful result, however, soon brought them to the conviction, that the refusal of the silk to conduct the electric fluid was not owing to its fineness, but proceeded from some inherent property possessed by the material. The metallic wires were smaller even than their silken thread had been, and yet they effectually carried off the electricity: thicker silken cords were therefore adopted, and, as before, the electric fluid was conveyed to a great horizontal distance, without suffering any diminution of its virtue.

This knowledge of the non-conducting power of silk was quickly followed by the discovery of the same quality in many other substances, and thus accidentally was laid the foundation of many of the subsequent improvements in the science of electricity.

No particular attention was paid to the electric qualities of silk, nor were any experiments made on it as an electric, until the year 1759. Mr. Symmer's notice was then attracted to the subject by the following whimsical circumstance, which led him to the performance of many curious experiments. The results of these he communicated to the Royal Society, by whom his paper was inserted in the fifty-first volume of their "Transactions."

Mr. Symmer was in the habit of wearing at the same time two pairs of silk stockings; the under pair white, and the upper black. If these were pulled off together, no sign of electricity appeared; but if the black stockings were pulled off from the white, a snapping or crackling noise was heard; and when this happened in the dark, sparks were plainly perceived between them. Thus incited, their philosophic wearer proceeded to make some further observations on the subject. He found, that by merely drawing his hand several times backwards and forwards over his leg while the stockings were upon it, he produced, in great perfection, the following appearances.

On the stockings being taken off separately and held within a certain distance of each other, both appeared to be highly excited, the white stocking vitreously; the black one resinously.* While kept at a small distance from each other, they were so inflated that they exhibited the entire shape of his leg; and if brought somewhat nearer, would immediately rush together. The inflation gradually subsided as they thus approached, and their attraction of extraneous objects diminished as their mutual attraction increased, so that when they actually met, they became flat and adhered together like so many folds of silk. On being again separated, their electric powers did not seem to be at all impaired, and they continued for a considerable time to afford a repetition of these appearances. If the two white stockings were held in one hand, and the black ones in the other, they were thrown into a strange agitation, owing to the attraction exercised between those of different colours, and the repulsion between those of the same colour. This conflicting of attractions and repulsions caused the stockings to rush to each other from greater distances than they would otherwise have done, and "afforded a very curious spectacle."

If the stockings were allowed to meet, they adhered together with considerable force. They required at one

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[*] Vitreous and resinous electricity used to be termed positive and negative.

time a weight of twelve ounces for their separation; and on another occasion, when they were more highly electrified, they sustained, in a direction parallel to their surface, as much as seventeen ounces, which was twenty times the weight of the stockings. If one were placed within the other, it required a weight equal to twenty ounces to separate them, although half this sufficed for the purpose if the stockings were applied to each other externally.

The black stockings being newly dyed, and the white ones first washed and then bleached by exposure to the vapour of sulphur, their mutual attraction was seen to be much increased. Under these circumstances, if one was placed within the other with their rough sides together, it required a force of three pounds three ounces to separate them.

With stockings of more substantial make, the cohesion was found to be still stronger. A white stocking of this description was placed within a black one of similar quality, first with the right side of one contiguous to the wrong side of the other, and afterwards with the two rough surfaces touching each other: in the first case they raised nearly nine pounds, and in the second, the still more surprising weight of fifteen pounds, without separating their surfaces. The tufts and ends of silk which are generally found on the inside of stockings considerably assisted towards the result of these experiments, which were not nearly so striking after these tufts were removed.

In the course of his experiments, Mr. Symmer also discovered that black and white silk, when highly electrified, not only cohere to each other, but will also adhere to any broad and to any polished surfaces, even although these bodies should not be themselves electrified. Having undesignedly thrown a stocking out of his hand, it struck against the side of the apartment, and adhered to the paper-hangings. He repeated the experiment, and found that the stocking would continue its adhesion for nearly an hour. Placing a black and a white stocking against the wall in this manner, he applied the two others to them, which had previously been highly electrified; and putting the white to the black and the black to the white, he carried them off from the wall, each of them hanging to that which had drawn it from its situation. When the stockings were applied to the smooth surface of a looking-glass, they adhered even more tenaciously.

Similar experiments, combining a greater variety of circumstances, were afterwards made with white and black ribands by Mr. Cigna of Turin, an account of which was published in the memoirs of the Academy of that city for the year 1765.

Having dried before the fire two white silk ribands, and extended them upon a smooth plane, he then several times drew over them the sharp edge of an ivory rule, and found that both ribands had by this friction acquired sufficient electricity to adhere to the plane, although they gave no indications of being in this state of excitement during their continuance upon it. It was not at all material to the success of the experiment, whether this plane was itself an electric or non-electric substance. When taken up separately, the ribands both appeared to be resinously electrified, and repelled each other: on dividing them, electric sparks were perceived between them, but on being again forced together or placed on the plane, no sparks were given off until they had been again excited by friction. When by means of the ivory rule they had thus acquired the resinous electricity, if, instead of being replaced on the smooth body whereon they had been rubbed, the ribands were applied to a rough conducting surface, they would on their subsequent separation show contrary states of electricity, which would again disappear on their being brought together. If after having been made by friction to repel each other, they were forced together upon such a rough surface, they would in a few minutes be mutually attracted, the under one being vitreously and the upper riband resinously electrified.

If the two ribands were subjected to friction upon a rough surface, they uniformly acquired contrary states of electricity, the upper being resinously and the lower one vitreously affected, in whatever manner they might be taken off. The same change was instantaneously produced by the use of any pointed conductor. If, for instance, the two ribands having been made to repel each other, the point of a needle were drawn along the whole length of one, it would cause both instantly to rush together. The same means employed to effect a change of electricity in a riband already electrified, would communicate electricity to the other which had not yet received the excitement. An unelectrified riband would become electrified if placed upon a rough surface and an electrified riband were put upon it, or if the one were held parallel to the other and a pointed conductor were presented.

Upon a smooth surface, Mr. Cigna placed a riband that was not quite dry, and applied over it another that had been well dried before the fire, when, after applying to them the usual friction with the ivory rule, he found that, in whatever manner they were removed from the surface, the upper one was always resinously and the lower one vitreously electrified. Exactly the same results were produced if the ribands employed were black instead of white. If any kind of skin, or if a piece of smooth glass, were used in place of the ivory rule, the effect was exactly the same; but if a roll of sulphur were substituted, the ribands then uniformly acquired the vitreously electric state: when rubbed with paper, either gilt or not gilt, the effects were uncertain. If the ribands were placed between folds of paper on a plane surface, and friction were then applied to them, both ribands acquired the resinous electricity. When one riband was black, and the other white, the black generally acquired the resinous and the white the vitreous state, whatever might have been their relative position, or the manner of applying friction.

Mr. Cigna likewise observed, that when the texture of the upper piece of silk was loose, yielding, or retiform, like that of a stocking, so that its elasticity caused it to move up and down with the corresponding movements of the rubber against the surface of the lower riband; and if the rubber employed were of such a nature as to communicate but little electricity to glass, the excitement did not depend upon the action of the rubber, but upon the body whereon it was placed. In such a case, the black silk was always resinously and the white vitreously affected. But if the riband was of a close unyielding texture, and the nature of the rubber such as would communicate a high degree of electricity to glass, then the excitement of the upper piece depended altogether upon the rubber. Thus, if a white silk stocking were rubbed with gilt paper upon glass, it became resinously and the glass vitreously electrified; but if the piece of silk thus placed upon the plate of glass were of a firmer texture, it was always electrified vitreously and the glass resinously, when sulphur was employed as the rubber; and most generally the same effect followed the use of gilt paper.

If an electrified riband were brought near to an insulated plate of lead, it would be very feebly attracted. If then a finger were brought nigh to the lead, a spark might be observed to pass, and the riband was powerfully attracted, but showed no further sign of electric excitement after coming in contact with the metal. On their separation, however, both substances appeared again electrified, and a spark passed between the plate and the finger.

If several ribands of the same colour were placed on each other upon a smooth conducting surface, and rubbed with a ruler, each, on being taken singly up, gave out sparks at its point of separation from the others; and on the removal of the last riband, a spark would equally pass between it and the conductor. If all were drawn from the plate together, they cohered in one mass, which was resinously electrified on both sides. If after this they were laid together on a rough conductor, and then separated singly, beginning with that which had been at bottom and next to the smooth conductor, sparks appeared as before, and all the ribands, with the exception of that at the top, were electrified vitreously. If friction were applied to them upon the rough conductor, and all were taken up without separation, the intermediate ribands acquired the electric state of either the highest or lowest, according as the separation was begun with either the one or the other. When two ribands were removed together from the rest, they clung to each other, and exhibited none of those indications of excitement which one, if taken alone, would have shown. When these two were separated, that which had been the outer one was found to have acquired electricity of an opposite nature to that of the remaining undivided ribands, but in a much weaker degree.

Several ribands were placed upon a metallic plate, which was charged with electricity by means of a glass globe and a pointed conductor held to the side opposite to the ribands. The effect of this was, that all of these became electrified; but whether the state of their excitement was like to or differing from that of the plate, depended altogether on the manner of their removal, except that the riband which was most remote always exhibited the opposite state of electricity to that of the metallic plate.

Numerous other experiments, equally simple and easy of accomplishment, may be made on the electric properties of silk, which are, no doubt, familiar to such persons as have at all attended to the science of electricity. Silk, more remarkably than any other substance, exhibits a strong and permanent attractive and repulsive electric power. Its property of exciting electricity by friction is of extensive application, causing it to hold an important place among the substances employed to exhibit the wonders of this science: silk always forms part of the apparatus of electrifying machines.

No attempt has been here made to bring forward any thing new, or that has not been long well known upon the subject; but as many persons are prone to consider that experiments on scientific subjects must necessarily be invested with complexity, which places them beyond accomplishment by the uninitiated, the above trifling detail will serve to prove the fallacy of this opinion. The inartificial nature of the operations places them within the reach of all who are disposed to repeat them; and some natural phenomena may thus be brought within the observation of every one; adding one more instance to the crowd of examples wherewith we are surrounded, that the most simple substances of daily use, whose qualities of beauty or convenience are alone understood by the multitude, may be made to afford to the mind of the enquirer matter for philosophical amusement and instruction.

NOTES.

Note A. page 3.

It has been well observed, "That throughout this extensive empire, embracing so great a variety of climate, the physical and moral qualities of the people remain as fixed and unchangeable as the laws and customs from which, in fact, they receive their colour. Such is the force of ancient usage and the dread of innovation, that a Chinese never stops to enquire what he ought to do on any pressing emergency, but what Yao and Chun did in a similar case four thousand years ago. Time, in fact, may be said to stand still in China. Here not only the system of morals, of social intercourse, of jurisprudence, of government, is the same now as it was three thousand years ago; but the cut of their robes, their houses, and furniture, are precisely the same: so that if custom has exercised its dominion over this singular people, they have at least been freed from the tyranny of fashion.

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The maxims of the sovereigns and sages of antiquity, — the rites and ceremonies and duties required by the civil and religious institutions of the empire, the laws and customs — are the points of knowledge which lead to wealth, power, and distinction in the state." Sup. Ency. Brit. art. *China*. These people, therefore, have no motive for joining in the race of improvement; while it has always been the policy of their government to check and entirely to repress all desire of change.

Note B. page 5.

Macpherson, in his Annals of Commerce, to which valuable work the author is indebted for many of the dates and facts recorded in this volume, remarks, with great appearance of probability, that perhaps the Seres were themselves the authors of this fable; thus making it appear to foreigners that the advantage was a blessing showered down peculiarly on their own favoured country, and one in which others could not participate.

Note C. page 6.

There have been many speculations formed for unravelling a subject which is involved in so much mystery. One of the most ingenious among these is found in the following note to Marsden's translation of the Travels of Marco Polo: — "I have long entertained the idea that the golden fleece which Jason carried off from Colchis was a cargo, or perhaps only a skein, of rich golden-coloured raw silk in the hank, which might figuratively be termed a fleece, because it was to be twisted into thread and interwoven into cloth. This, at least, is as plausible as the commonly received solution, admitted by a celebrated historian not prone to credulity."

Note D. page 7.

Nearchus, Aristobulus, Theophrastus, Virgil, Dionysius Periegetes, Seneca, Arrian, Solinus, Ammianus Marcellinus, Claudian, Jerome, &c.

Note E. page 8.

Publius Syrus, Varro, Tibullus, Propertius, Horace, Seneca, Pliny, and Juvenal.

Pliny, l. xi. c. 23. Tacit. Ann. l. ii. c. 32.

Note F. page 9.

"Réflexions sur les Liaisons des Romains avec les Tartares et les Chinois," by M. de Guignes, in Mémoires de Littérature, vol. xxxii. p. 355. It is said, indeed, by Florus, lib. iv. c. 12., that ambassadors came from the Seres to court the favour of Augustus; but this is not very probable, as in the whole course of the history of this people it appears that they were never desirous of any alliance or intercourse with other nations.

Note G. page 9.

By the Rhodian naval laws, preserved in the eleventh book of the Digests, unmixed silk goods when shipwrecked, if they were preserved free from wet, paid a salvage of 10 per cent., as being equal to gold in value.

Note H. page 17.

Otho Frising. de Gest. Frederici, l. i. c. 33.; apud Muratori, Script. vol. vi. col. 668. Falcandi Hist. Sicul. præf.; ap. Muratori, Script. vol. vii. col. 256.

Note I. page 19.

The ancient Chinese are said to have extended their voyages as far from home as the coast of Africa,—a degree of maritime adventure which does not receive much confirmation from our knowledge of the channels through which, in those remote times, commercial intercourse was carried forward in the East. According to Cosmas, the Indians who traded with the Chinese were accustomed to resort to Ceylon, where alone they received silks, spices, and other valuable productions, which were thence distributed among the different marts of India. Gibbon, in the fifth volume of the "Decline and

Fall of the Roman Empire," thus describes the mode of prosecuting this commerce: — "The Chinese and Indian navigators were conducted by the flight of birds and periodical winds, and the ocean might be securely traversed in square-built ships, which, instead of iron, were sewed together with the strong thread of the cocoa-nut. Ceylon, Serendip, or Taprobana, was divided between two hostile princes; one of whom possessed the mountains, the elephants, and the luminous carbuncle, and the other enjoyed the more sordid riches of domestic industry, foreign trade, and the capacious harbour of Trinquemale, which received and dismissed the fleets of the East and West. In this hospitable isle, at an equal distance (as it was computed) from their respective countries, the silk merchants of China, who had collected in their voyages, aloes, cloves, nutmegs, and sandal wood, maintained a free and beneficial commerce with the inhabitants of the Persian Gulf."

Note K. page 36.

The project of rearing silkworms in the United States of America has very recently been renewed, and a small package of silk, the result of this attempt, was, early in the present year (1831), imported into Liverpool.

The President of the American Philosophical Society established in Philadelphia, M. Duponceau, has for some time been desirous of encouraging this branch of rural economy, and lately established a filature, under the direction of a gentleman, who, having conducted a similar undertaking at Nismes in France, is possessed of the requisite knowledge and experience.

The quality of the silk hitherto produced in Pennsylvania is said fully to equal that of Bengal: it promises to stand well the various processes of dyeing, throwing, and weaving; but, as might be expected in the commencement of such an undertaking, the operation of reeling has not been conducted with the requisite degree of skill. The attempt has hitherto been made on too small a scale for the projector to form any satisfactory opinion upon the issue as regards its profitableness; and it yet remains to be seen whether the Philadelphians are in possession of facilities for this pursuit, which will counterbalance the high rate of wages prevalent throughout the state, and which would otherwise give a decided advantage in point of price to the raw silks of Italy and India, even in the markets of the United States.

The subject has appeared to be of so much importance to the American legislature, that a committee of congress has recommended the project to the attention and protection of the government.

Note L. page 51.

It is the policy of many of the states of Italy rigidly to exclude British manufactured goods from their territories. Yet as we annually take from them merchandise, principally raw silk, to the value of two millions sterling, and as no exportation of the precious metals is made in payment for the same, it became a question in what shape and by what channels the Italian merchants obtained returns for their produce. Upon investigation, it appeared that the foreign traders took their remuneration in bills of exchange drawn upon the London merchants, by far the largest portion of which were remitted to Manchester and Glasgow from Austria and the German states, in return for those products of British industry against which the Italian governments so strictly closed their ports. It is indeed hopeless for any nation, so long as it has productions of its own for sale, thus to attempt the exclusion of the produce of another country; and perhaps the only consequence of such short-sighted policy will be the enhancement to themselves of the prices of foreign productions.

Note M. page 84.

There is a very strong analogy between the course pursued, up to a recent period, by the English government, with reference to the trade in thrown and manufactured silk, and that followed by the government of France in respect of the introduction of materials for their cotton manufactures. The spinners of fine cotton-yarns in the latter country having asked for protection against the importation of yarns of that quality, a very large prohibitory duty was accordingly imposed. The consequence of this measure was, that the manufacturers of the better qualities of muslin not being able to dispense with the use of the fine yarns which they had been accustomed to import, and the French spinners being unable to furnish them with any substitute, the smuggler was immediately put into active occupation, and, notwithstanding the vigilance wherewith revenue restrictions were enforced by the aid of military cordons, passed through them all, and furnished to the manufacturer the fine yarns of England at an advance in price of from 60 to 70 per cent., so that the French spinner gained nothing by the prohibition.

The peculiar circumstances which accompanied the state of war, enabled the French manufacturer at that time to prosper even under this disadvantage; but when, at the return of peace, the illicit traders proceeded to introduce English muslins ready manufactured, at an advance upon English prices of only from 17 to 25 per cent., both the spinners and weavers were completely ruined.

Note N. page 84.

At the time when the last alteration was made in the rate of duties charged upon foreign manufactured silk goods (April, 1829,) it was stated in the house of commons by the then vice-president of the Board of Trade, the right honourable Vesey Fitzgerald, on the authority of French merchants, that the total cost of smuggling *and insuring* gros-de-naples was from 28 to 29 per cent. upon their value; that the same charges upon satin ribands amounted to from 24 to 25 per cent.; upon sarcenet ribands, 25 to 26 per cent; figured gauze, 28 to 29 per cent.; blonde, 12 to 13 per cent. The smaller rate, in the latter case, being occasioned by the greater value of the article in proportion to its bulk, which rendered the object of the smuggler easier of accomplishment. It was further stated that crèpe-lisse, crape, and plain gauzes, had not been smuggled at any time since their importation had been legalised by the imposition of a duty.

NOTE O. page 86.

The evil effects of prohibitory laws upon the moral feelings of the community were thus eloquently enforced by Mr. Vesey Fitzgerald, on the occasion to which reference has been made in the preceding Note. "Under prohibition the trade was a scene of offensive and arbitrary laws, restrictive of the fair exercise of the inclinations of the people, and regardless of their wants. They were laws which no one felt to impose any moral obligation, and thus an habitual indifference to the breach of law was engendered in the public mind. But I have said they were inefficacious, and will the house encourage those who avow that the object of their enquiry is to establish a return to them? I will remove from the statute book, if I can, legal crimes which the people do not view as moral crimes! I would not arm the common informer with a power to enter the houses of individuals; I would not permit even the king's officer, for the sake of a fiscal regulation, to violate the sanctity of every Englishman's abode. I cannot afford to protect the manufacture by such odious laws; and least of all, when I find that such a power never did put down smuggling, but that, with all these vile appliances and bad means to boot, it was absolutely inefficacious."

NOTE P. page 87.

Simond, who visited Lyons in 1817, has described the poverty of the silk-weavers resident in and near that city, as being more abject than any thing within the experience of our own artisans. There, as with us, the manufacture is in a great degree domestic, most of the weavers executing their labour in their own dwellings. The abodes of the French weavers are, however, wretched in the extreme, one room, twenty feet square, not unfrequently serving every purpose, both as a dwelling and workshop, for three entire families.*

NOTE Q. page 89.

Experience has almost uniformly proved, that low-priced labour is, in the end, dear labour to the employer. In contrasting the rate of wages paid in different countries for work of the same description, we should not only look to the amount of money which goes to recompense the daily toil of the artisan, but must also take into the account the number of hours during which he works, the constancy wherewith he applies himself to his labour, and the skill which he brings to its accomplishment. If the question of wages, as affecting the cost of manufactures in England, be examined by these tests, it will in most cases be found that the dearness of labour with us is more nominal than real.

This position, although more obviously true in branches where labour is remunerated according to the time expended, cannot yet be made to appear incorrect in any case unfettered by legislative interference; and there is no good reason for doubting that the constantly increasing skill of our silk-weavers would, if the trade were rendered perfectly free, soon give to the productions of their looms a value more than equivalent to any difference that may exist between the money rate of wages at Lyons and in Spitalfields.

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* Tour and Residence in Switzerland, vol. i. p. 317.

Note R. page 95.

The bark of this tree not only furnishes fibres for ropes, but it can even be formed into a species of cloth. M. la Rouverie affirms, that he procured a beautiful vegetable silk from the young branches of this species of mulberry; cutting the bark while the tree was in sap, and then beating it with mallets and steeping it in water, he obtained a thread from the fibres, almost equal to silk in quality, and this was woven into a cloth whose texture appeared as if formed of that material. The women of Louisiana obtain a similar production from the offshoots of the mulberry; these are gathered when they are about four or five feet high. The bark is stripped and dried in the sun: it is then beaten, to get rid of the external part, which falls off, leaving the inner bark entire. This is again beaten, to make it still finer, after which it is bleached in dew. It is then spun, and various fabrics are made from it, such as nets and fringes, and sometimes it is woven into cloth. The finest sort of cloth among the inhabitants of Otaheite, and other of the South Sea Islands, is made of the bark of this tree.

Note S. page 95.

The wood of the mulberry tree is used for many purposes. Its being compact, pliant, and hard, capable of receiving a good polish, causes it to be sought by upholsterers, turners, and carvers. Its strength makes it useful to the joiner, and its power of resisting the action of water almost as well as oak, makes it good timber for building boats. It is also a very good wood for fuel, and it is well adapted for making charcoal.—MAYET *sur le Culture du Mûrier.*

Note T. page 95.

In the European silk countries a great many varieties of mulberry trees are distinguished, arising from difference of climate, soil, method of culture, and other accidental causes. Among the wild mulberries there are some bearing roundish leaves resembling those of a rose—hence they have obtained the name of the Rose-leaved mulberry. The mulberry called the Roman Leaf is distinguished from every other species by its very large leaves, some of which are frequently found equal in size to those of a gourd.

The Spanish greatly resembles the wild rose mulberry, except that its leaves are larger and more pointed. It is by no means delicate, and can resist the strongest frosts of the severest winters in cold climates.

The leaves of the mulberry called the Small Queen are oblong, moderately large, and exceedingly smooth: this species is of an excellent quality, and much esteemed.

Note U. page 96.

Arthur Young observed "many noble black mulberry trees in Provence and Piedmont, which were never stripped, but kept for the fruit merely—

the silk being considered inferior that is produced from them; Bertezen affirms, that in Italy and France the leaves of the black mulberry are regarded as poison to the worms.

Note V. page 111.

If at this time any of the threads intended for the support of the cocoon should be broken, the worm will find, in the progress of its work, that the ball, not being properly poised, becomes unsteady, so that the insect is unable properly to go forward with its labours. Under these circumstances the worm pierces and altogether quits the unfinished cocoon, and throws out its remaining threads at random wherever it passes, by which means the silk is wholly lost, and the worm, finding no place wherein to prepare for its last change, dies without having effected it. It may sometimes happen, but such a thing is of infrequent occurrence, that the preparatory threads before mentioned are broken by another worm working in the neighbourhood, when the same unsatisfactory result will be experienced.—*Obs. on the Culture of Silk, by* A. Stephenson.

Note W. page 123.

Mons Marteloy of Montpelier, who made many experiments upon the rearing of silkworms, presented a memorial upon the subject to the French minister, in compliance with whose recommendation the states of Languedoc caused an experiment to be conducted publicly in the open air, in the garden belonging to the Jesuits' college at Montpelier. The whole was placed under the direction of Mons. Marteloy, who had 1200 livres assigned to him to defray the necessary expenses. The experiment succeeded perfectly. This was in 1764. On the following year a second trial was made, and 1800 livres were set apart for the expenses. Owing, however, to the unfavourable nature of the season, this experiment failed entirely, the heavy and incessant rains making it impossible to keep the food of the worms in a sufficiently dry state. The rearing of silkworms in the open air was not again attempted in that quarter; but the partial success led to the adoption among cultivators of a better system of ventilation, and the production of silk was about this time very much extended throughout Languedoc.—*Obs. on the Culture of Silk, by* A. Stephenson.

Note X. page 138.

It is the practice at Montauban, in Quercy, to employ shallow circular willow baskets; which are furnished with brush-wood for the spinning of the worms. The wood is ranged round two thirds of the basket, the remaining space being left for putting in the worms and for clearing away the litter. The ends of the wood are pulled together at the top, and kept in that position by tying them with packthread; after which a paper cap is placed loosely over the top, the cover being thought agreeable to the worms: the brush-wood rises three or four feet above the rim of the basket.

This is thought to be an excellent contrivance, as it keeps the worms more cool and airy than when they are placed in arbours on a stage, but it is expensive, and occupies more space than can usually be allotted for the purpose.—*Obs. on the Culture of Silk, by* A. STEPHENSON.

NOTE Y page 146.

Monsieur Baumé, finding that the method usually pursued for destroying the chrysalides previous to reeling the silk, rendered it hard, and that the cocoons were then reeled with more difficulty than in cases where no artificial heat had been employed, proposed to modify this by using for the purpose the steam of spirit of wine, which vaporises at a temperature much below that of boiling water. According to the testimony of this able chemist, silk thus treated proves susceptible of assuming a greater lustre than that which has been baked. The process used by M. Baumé, as described in the *Annales de Chimie*, was to dispose the cocoons within a wooden box, in a stratum six inches deep, upon each superficial square foot of these, half a pint of spirit of wine was sprinkled from a watering-pot, so as to distribute the liquid equally over the cocoons. Another stratum was then formed over these, and a further quantity of spirit applied, and so on until the box was filled. This being then covered closely up, and left during twenty-four hours, the whole became spontaneously heated to a degree sufficient to vaporise the spirit, which, in that form penetrated the cocoons, and acted with energy sufficient to destroy the vitality of the chrysalides. The cocoons having after this been spread out to dry, were then ready for being reeled. Baumé states, that silk thus treated, not only will exhibit a greater lustre, but that the proportion reeled will be one ninth part greater than when the heat of an oven has been employed.

NOTE Z. page 150.

The Society for the Encouragement of Arts, &c., after having for a series of years proffered rewards to stimulate the culture of silk in England, appears to be convinced of the improbability that this can ever be made a profitable branch of industry with us. From time to time attempts were made by persons whose means and intelligence fully qualified them for the undertaking, and some few rewards were adjudged by the society upon the production of the specified quantities of silk. In no case, however, did any practical good follow upon these attempts, and the society now limits its patronage in this branch of the useful arts to the furtherance of silk production in the British colonies, and to improvements in the quality of such as is raised in British India.

NOTE AA. page 157.

Tobacco is found to be a deadly poison to silkworms. If a few grains of snuff are suffered to fall upon one of them, immediate signs of agitation and distress will be produced, and in the course of one minute the sufferer will be thrown into convulsions which speedily end in death. Just before expiring, the insect casts from its mouth a watery substance; and if any other worm should happen to be touched by this fluid, the like fatal effects will ensue.—*Obs. on the Culture of Silk, by* A. Stephenson, Esq.

Note BB. page 158.

"There is in the order of nature a certain and very surprising fact; when the leaves of vegetables are struck by the sun's rays, they exhale an immense quantity of vital air necessary to the life of animals, and which they consume by respiration.

"These same leaves in the shade and in darkness exhale an immense quantity of mephitic or fixed air, which cannot be breathed, and in which animals would perish.

"This influence of the sun does not cease even when the leaf has been recently gathered; on the contrary, in darkness, gathered leaves will exhale a still greater quantity of mephitic air.

"Place one ounce of fresh mulberry leaves in a wide-necked bottle of the size of a Paris pint, containing two pounds of liquid; expose this bottle to the sun; about an hour afterwards, according to the intensity of the sun, reverse the bottle and introduce a lighted taper in it, the light will become brighter, whiter, and larger, which proves that the vital air contained in the bottle has increased by that which has disengaged itself from the leaves: to demonstrate this phenomenon more clearly, a taper may be put in a similar bottle, that only contains the air that has entered into it by its being uncorked. Shortly after the first experiment, water will be found in the bottle which contained the mulberry leaves; this water, evaporating from the leaves by means of the heat, hangs on the sides, and runs to the bottom when cooling; the leaves appear more or less withered and dry according to the liquid they have lost. In another similar bottle place an ounce of leaves, and cork it exactly like the former; place it in obscurity, either in a box, or wrap it in cloths, in short, so as totally to exclude light; about two hours after open the bottle, and put either a lighted taper or a small bird into it; the candle will go out, and the bird will perish, as if they had been plunged into water, which demonstrates that in darkness the leaves have exhaled mephitic air, while in the sun they exhaled vital air."—Count Dandolo.

Note CC. page 169.

Naturalists, as well as antiquarians, were formerly prone to investigations which, to the unenlightened and uninitiated, might, perhaps, appear bordering on the ridiculous. It would seem that, in their curious computations, they rather sought to surpass the wonders related by some rival microscopic observer, than to adhere to the rigidness of mathematical calculation, or keep within the limits of rational probability. They, indeed, became lost and bewildered in the very minuteness of their subject. M. Leuwenhoek has computed, that a hundred of the single threads of a full-grown spider are not equal to the diameter of one single hair of his beard, and consequently if the threads and hair be both round, ten thousand threads are not bigger than such a hair! He calculates farther, that when a young spider begins to spin, four hundred of these are not larger than one which is of full growth, allowing which, four millions of the single filaments of a young spider's web were not so big as a single hair of his beard!

A strange calculation — very probably wrong in its data, and most certainly so in the conclusions deduced.

Note DD. page 180.

According to Aristotle, byssus was formed from the beard of the pinna; but the name appears to have been used indiscriminately by other writers for any material that was spun, and the quality of which was finer and more valuable than woollen threads.

Note EE. page 181.

The fourth volume of Nicholson's Journal of Natural Philosophy contains a memoir on the insect fly-carrier, or cassada-worm, communicated to the American Philosophical Society, as the result of his own observations made in the island of St. Domingo, by M. Baudry des Lozières. The insect here mentioned is not itself endowed with the faculty of producing fibres, and yet is so curiously made the depositary of a substance of this nature by other animate creatures, that an abridged account of the phenomenon may be found interesting.

The insect fly-carrier is, like the silkworm, produced from eggs deposited by a butterfly of a whitish or light pearl colour. It is hatched about the latter end of July, and its developement is so rapid, that in September the worm is changed into a butterfly. It first comes forth decked in a robe of the most brilliant and variegated colours, differing in this respect from the silkworm, which it otherwise resembles in external shape. It feeds upon the leaves of the indigo and cassada plants, and as its devouring is carried forward day and night with scarcely any intermission, the ravages which it commits are considered as a serious evil by the planters, whose attention has, for this reason, been more bestowed upon endeavours to destroy it, than upon considering in what manner to derive any advantage from its existence.

In the month of August the worm undergoes one of its changes, and putting off the beauteous covering wherein it first exhibited itself, appears of only one colour — a sea-green — reflecting all the shades of that colour, "according to the different undulations of the animal, and the different accidents of light." This metamorphosis is the signal of attack from a species of the ichneumon fly, — a very small insect, which has obtained this name through the benefit it renders to man in the destruction of various hurtful insects, and in which respect it is perhaps equally serviceable with the quadruped whose name it has thus been made to bear, and which demolishes the young of more formidable though less numerous reptiles. These flies assail the cassada-worm in such swarms, that it is affirmed there is not one spot on its back and sides left visibly uncovered by them. Proceeding immediately to drive the stings wherewith they are armed through the skin of the worm, the flies deposit their eggs in the bottoms of the wounds they inflict. During this painful operation, the cassada-worm exhibits all the signs of intense suffering, struggling and writhing, and using every effort to shake off its cruel tormentors.

So soon as the flies have accomplished their object in safely depositing their eggs, they disappear; the worm seems exhausted with its previous efforts, and remains for about an hour in a state of lethargy, from which however, it then awakes, to feed with renewed avidity.

In about fourteen days after having thus been made the unwilling depositary of these eggs, and during which time the worm increases daily in size, it is seen to be completely covered with a living robe of animalculæ, having a deep brown colour, so that no more than the top of its head can be perceived. If the operations of these newly-hatched worms are then carefully examined, it will be seen that each, raising itself upon its hinder extremity, swings its head and body to and fro in every direction, and forms for itself an almost imperceptibly small egg-shaped cocoon, remaining, like the silkworm, in the interior of the ball, making thus, as it were, its own winding-sheet, and seeming born but to die.

These millions upon millions of cocoons, as they are described by M. des Lozières, the formation of which has not occupied a greater space of time than two hours, are placed so closely together that they form a white robe in which the insect fly-carrier appears elegantly clothed. During this process of decoration the worm remains in a state of torpidity: but no sooner is the robe fully completed, than the wearer seeks to disencumber itself of its guests, and, after efforts of some duration, and which appear greatly to exhaust its frame, succeeds in the endeavour. Its appetite is now gone; it speedily passes to the state of a chrysalis; then becomes a butterfly; and, after giving birth to many hundred eggs, appears thus to have fulfilled the end of its being, and dies.

When about eight days have elapsed from the first formation of the minute cocoons by the larvæ, ichneumon flies issue from these, leaving the fibrous substance pure, beautifully fine, and of a dazzling whiteness. This, without any previous preparation, may be immediately carded and spun. According to the opinion expressed by M. des Lozières, it is greatly superior in every respect to vegetable cotton, while in some particulars it is even preferable to the produce of the silkworm; requiring less of time and trouble for its production, and being greatly more abundant in its produce.

It is now, however, nearly forty years since the observations of M. des Lozières were given to the world, and no attempts have been made to realise the advantages which he promised from the pursuit.

Note FF. page 214.

The superior fineness of some Indian muslins, and their quality of retaining, longer than European fabrics, an appearance of excellence, has occasioned a belief that the cotton wool of which they are woven is superior to any known elsewhere: this, however, is so far from being the fact, that no cotton is to be found in India which at all equals in quality the better kinds produced in the United States of America. The excellence of India muslins must be wholly ascribed to the skilfulness and patience of the workmen, as shown in the different processes of spinning and weaving. Their yarn is spun upon the distaff, and it is owing to the dexterous use of the finger and thumb in forming the thread, and to the moisture which it thus imbibes, that its fibres are more perfectly incorporated than they can be through the employment of any mechanical substitutes. The weaving art is pursued to such an extent throughout the peninsula, that, according to Mr. Orme (*Historical Fragments of the Mogul Empire*), " it is difficult, when not near the high road, or a principal town, to find a village in which every man, woman, and child, is not employed in making a piece of cloth." Among the multitudes thus trained from childhood to the pursuit of a simple occupation, it would be surprising if some individuals did not attain the capability of producing superior fabrics. The very fine muslins, which thus attest the proficiency of some of the Indians, and which have been poetically described as "webs of woven wind," are, however, viewed as curiosities even in the country of their production, and are made only in small quantities; so that their use is limited, almost exclusively, to the princes of the land.

Note GG. page 249.

It sometimes happens that various branches of occupation in the silk manufacture are carried on under the same roof, by different members of the same family. It once occurred to the author of this treatise, in the course of his visits among the operative weavers in the district of Spitalfields, to visit a family consisting of a man, his wife, and ten children, all of whom, with the exception of the two youngest girls, were engaged in useful employments connected with the silk manufacture.

The father, assisted by one of his sons, was occupied with a machine, such as is mentioned in page 259. punching card slips from figures which another son, a fine intelligent lad about thirteen years of age, was " reading on." Two other lads, somewhat older, were in another apartment, casting, drawing, punching, and attaching to cords the leaden plummets or lingos, which form part of the harness for a Jacquard loom. The mother was engaged in warping silk, with a machine similar to that described by *fig.* 7 page 219 One of the daughters was similarly employed at another machine, and three other girls were in three separate looms, weaving figured silks, one by the aid of the mechanical draw-boy, described at page 239. (*figs* 15, 16, 17, and 18), the others with Jacquard machines.

An air of order and cheerfulness prevailed throughout this busy establishment that was truly gratifying; and, with the exception of the plummet-drawers, all were clean and neatly clad. The particular occupation wherein each was engaged, was explained most readily, and with a degree of genuine politeness, which proved, that amid the harassing cares attendant upon daily toils of no ordinary degree, these parents had not been unmindful of their duty, as regarded the cultivation of their children's minds and hearts.

Note HH. page 307.

Material substances have generally been divided into two classes, electrics and non-electrics; which distinction, if taken strictly, is not correct; there is no positive line of demarcation between the two. There is not any electric or non-conducting substance that is a perfect insulator; neither is there any non-electric or conducting substance that cannot, by friction, be made capable of exhibiting electrical phenomena.

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